Strategic planning of Supply Chains in Global Emergency Logistics

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Yousef Lutfi Abdel Latif Abu Nahleh
M. Eng.

School of Aerospace, Mechanical and Manufacturing Engineering
College of Science, Engineering and Health
RMIT University
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Dr . Arun Kumar ,

and the secondary supervision of,

Dr . Fugen Daver ,

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by

Yousef Lutfi Abu Nahleh

Born on 30 October 1985

Thesis approved by:

Dr . Arun Kumar

Dr . Fugen Daver

Declaration

Except where due references are made, the work reported in this thesis is solely that of the author alone and has not been submitted or published previously, in whole or in parts, for any academic award.

The work that is reported in this thesis was carried out since the official date of commencement of the program, 16th of July 2012 at RMIT University.

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Abstract

This study discusses the basis of effort considered in defining and analysing the Critical Success Factors (CSFs) essential for ensuring that disaster aid logistics are both effective and appropriate. The study classifies, first, the elements which are most significant to Emergency Aid Organisations and Humanitarian Relief in providing an effective response in disaster situations, next, the variables which affect the efficiency of each. From field and desk research, the extent to which CSFs are understood and recognised within relief activities is evaluated. Furthermore, it merges the concept of Just In Time (JIT) and the campaign system in emergency supply chain, so that when the disaster happens the affected country can request help from the nearest regional warehouse, which will supply the relief material and the required stuff to support and assist the victims in the disaster area. The regional warehouse places an order to the continent warehouse to replenish the material that is distributed to the disaster area.

This study develops a forecasting tool based on identifying probability distributions. The estimates of the parameters are used to calculate natural disaster forecasts. Further, the determination of aggregate forecasts leads to efficient pre-disaster planning. Based on the research findings, the relief agencies can optimize the various resources allocation in emergency logistics planning.

Subsequently, a simulation model has been developed to integrate the forecasting tool with the proposed distribution network and the inventory stock. The simulation model has two stages; the first one is finding the demand, type of disaster and the location based on the forecasting models, followed by comparing the demand result with the actual number to validate the stage. Next stage of the model connects the demands with proposed distribution network and the inventory stock to find the waiting time to deliver the relief material. The proposed model does not exceed two days of waiting time.

This study investigates how natural disasters disturb supply chain processes in the Asia-Pacific context and how universal supply chains develop the risks of natural disasters. The study first discusses the emergence and development of global supply chains in the Asia-Pacific region and then examines how these new developments globalize disaster risks and bring extra vulnerability to businesses, particularly to their production networks. Following this, the study describes the impact of natural disasters on the global supply chains, on the basis of two natural disasters that occurred in 2011 in the region: the Great East Japan earthquake and the South-East Asian floods (focusing on the flood of Thailand). Finally, two policy options are proposed to enhance disaster resilience for business in the context of globalization.

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Journal Articles:

1. KUMAR, A,.LATIF YOUSEF, L.A & DAVER, F 2012, 'Developing Forecasting Tool for Humanitarian Relief Organizations in Emergency Logistics Planning', *World Academy of Science, Engineering and Technology,* vol. 71, pp.1687-1693.
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3. NAHLEH ,Y, KUMAR, A AND DAVER, F 2013 ' Facility Location Problem in Emergency Logistic ' , *World Academy of Science, Engineering and Technology ,* Vol:82 2013-11-02. **.**
4. ABU NAHLEH, Y, HAKAMI,A,, KUMAR, A AND DAVER, F 2013. 'Improving Order Quantity Model with Emergency Safety Stock (ESS) ' . *World Academy of Science, Engineering and Technology International Journal of Industrial Science and Engineering* Vol:7 No:12, 2013 **.**
5. HAKAMI, A, KUMAR, A, SHIM, S, AND ABU NAHLEH, Y, 2013. 'Application of Soft Systems Methodology in Solving Disaster Emergency Logistics Problems ' . *World Academy of Science, Engineering and Technology International Journal of Industrial Science and Engineering* Vol:7 No:12, 2013 **.**
6. ABU NAHLEH ,Y., KUMAR, A,. AND DAVER, F, 'Predicting type of disaster for Humanitarian Relief Organizations in Emergency Logistics Planning by using Ordinal Logistic Regression ', Accepted to publication in *International Journal of Engineering Business. Management.*
7. NAHLEH, Y, KUMAR, A , DAVER, F, AND AL-HINDAWI, R, 'Decision Tree Modeling in Emergency Logistics Planning' . *World Academy of Science, Engineering and Technology International Journal of Social, Management, Economics and Business Engineering* Vol:8 No:6, 2014

- **Conference publications:**

1. KUMAR, A,.LATIF YOUSEF, L.A AND DAVER, F 2012, 'Developing Forecasting Tool for Humanitarian Relief Organizations in Emergency Logistics Planning', Proceedings for presentation and publication in the proceedings of *International Conference on Industrial Engineering and Systems Management* ,November 28-29, Paris, France

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3. NAHLEH, Y, KUMAR, A AND DAVER, F 2013 'Predicting Relief Materials' Demand for Emergency Logistics Planning in Thailand' presented in *International Conference on Economics and Social Science*, January 20-21, Melbourne, Australia.
4. NAHLEH ,Y, KUMAR, A AND DAVER, F 2013 ' Facility Location Problem in Emergency Logistic ' Proceedings for presentation and publication in the proceedings of *International Conference on Industrial Engineering and Systems Management*, October 14-15 , Barcelona, Spain.
5. NAHLEH, Y, HAKAMI,A,, KUMAR, A AND DAVER, F 2013. 'Improving Order Quantity Model with Emergency Safety Stock (ESS) ' . Proceedings for presentation and publication in the proceedings of *International Conference on Mechanical, Aeronautical and Manufacturing Engineering* , December 16-17 , Melbourne, Australia.
6. HAKAMI, A, KUMAR, A, SHIM, S, AND NAHLEH, Y, 2013. 'Application of Soft Systems Methodology in Solving Disaster Emergency Logistics Problems ' . Proceedings for presentation and publication in the proceedings of *International Conference on Mechanical, Aeronautical and Manufacturing Engineering* , December 16-17 , Melbourne, Australia.
7. NAHLEH, Y, KUMAR, A AND DAVER, F, 2014 'Decision Tree Modeling in Emergency Logistics Planning'. Proceedings for presentation and publication in the proceedings of *International Conference on Industrial and Manufacturing Systems Engineering*, June, 19-20, 2014, Istanbul, Turkey.

CHAPTER 1

Introduction

1.1 Background and Introduction

There has been a marked increase in the occurrence of natural disasters such as earthquakes, tsunami, floods, bushfires, hurricanes, droughts and so on, globally during the last ten years along with exposure to greater levels of loss of life, and property damage. The number of natural disasters is increasing every year. For instance, during 1980s the average number of disasters per year was 180, in 1990s increased to 300, and in 2000 to 2010 it was 384, indicating a dramatic increase. As the number of disasters increases every year, more people are affected by these disasters. Comparing 2011 with the previous decade indicates that the number of victims increased from annual average number of 232.0 million for years 2001 to 2010, to 244.7 million victims worldwide.

In 2011, economic damages from the natural disasters were the highest ever registered, with an estimated US$366.1 billion, and rase by 235% compared to the yearly average losses between 2001 and 2010 (US$109.3 billion). Because of the population growth and new developments in risk prone regions, the exposure of the human kind to the natural disasters is increasing even more. A total of 101 countries were hit by these disasters last year. Over the previous decade, the United States, Indonesia, India, the Philippines and China constitute the highest five countries that are most frequently hit by natural disasters (Guha-Sapir et al., 2011b).

Asia was the most often hit by natural disasters in 2011 (44%), followed by Americas (28%), Africa (19.3%), Europe (5.4%) and Oceania (3.3%). Moreover, Asia accounted for 86.3 of victims affected, followed by Africa (9.2%). In 2011, Asia also has the greatest losses (75.4% of worldwide disaster damages), after that of the Americas (18.4%) and Oceania (5.6%). The earthquake and tsunami in Japan was the most expensive disaster ever recorded, with estimated economic losses of US$210 billion. Floods in Thailand caused a loss of US$40 billion, followed by earthquake in New Zealand (US$15 billion), and storms in the USA (US$14 billion). In terms of Gross Domestic Product (GDP), damages in Japan characterized 3.0% of the country's GDP, while losses from natural catastrophes in Cambodia and El Salvador – a low-income and low middle-income country, correspondingly – characterized 4.6% and 4.7% of the countries' GDPs. Thailand and New Zealand also suffered great economic losses amounting to 12.7% and 12.8% of their GDPs respectively (Bank, 2012;Guha-Sapir et al., 2011a) . Overall, during the past three decades, the number of reported disasters has increased fourfold, and around 6.1 billion people have been affected by disasters with an estimated damage of almost 2.3 trillion dollars (Kumar et al., 2012).

Immediately after the disaster, there is a huge surge of demand of relief materials with a short notice and the humanitarian relief organizations often face significant problems of emergency logistics management such as transporting large quantities of several different supplies including medicine, clothing, food, machinery, medical supplies, and personnel from numerous roots to several destinations inside the disaster zone. The transportation of relief personnel and supplies must be done professionally and rapidly to maximize the survival percentage of the affected people and decrease the cost of such processes. The demands in the relief chain occur in irregular amounts and at irregular intervals and occur suddenly, such that the locations are often completely unknown until the demand occurs. An acceptable level of mitigation measures and a corresponding post-disaster aid logistics management may support to decrease the loss of both economic damage and human lives. Time plays a serious part in the logistic strategy, and it directly affects the survival amount in affected zones. This makes the mission of supply chain management and logistics planning more complex than conventional distribution problems.

Humanitarian relief organizations and NGO’s are mostly non-profit organizations with the idea of providing critical services to the public in order to minimize the pain and sufferings after a natural disaster. According to UN Office for Humanitarian Affairs, there is increasing human vulnerability in natural disasters, 244.7 million affected in 2011, and in complex emergencies 54 million in need of life-saving assistance in 2011. Furthermore, emergency management involves preparing for disaster before it happens, responding to disasters immediately, as well as supporting, and rebuilding societies after the natural or human-made disasters have occurred. It is essential to have comprehensive emergency plans and evaluate and improve the plans continuously.

Where emergencies are sudden, roads impracticable or ground situations unsafe, or where much of the infrastructure has been damaged or destroyed, helicopters are used to deliver food and non-food items. Emergency logistics carries out helicopter airlifts to reach areas where fixed-wing aircraft cannot land. Helicopters have become an indispensable aid for dealing with disasters. People who have fallen victim to a disaster or are endangered by catastrophe cannot afford to delay till a “clearer picture” of the loss has been recognized. Helicopters can contribute towards establishing this picture, and are promptly called out as soon as “a major occurrence” has taken place.

Furthermore, managing supply chain network has become a vital global issue in the context of the severe effect of natural disasters and a wide variety of other reasons such as industrial plant fires, transportation delays, work stoppages, and it remains a largely unexplored area in research and practice. With increasing numbers of natural and man–made disasters, organizations are facing challenges due to limited number of available experienced logistics experts and the need for better coordination of those involved in vulnerable logistics networks. Moreover, companies running lean processes no longer have inventory or additional capability to make up for production losses, resulting into rapid escalation of material flow problems to wide-scale network disruptions. The dynamic nature of the global supply chain environment dictates that the companies with resilient supply chains in the future will have a supportable competitive benefit over other organizations.

The emergency supply chain differs from the normal supply chain in many ways such as huge surge of demand with a short notice, damaged roadways, chaotic behavior of victims, break-down of infrastructure and communication lines, short lead time, main uncertainties about what is really needed and what is existing at the location, large volumes of critical supplies to be transported and so on. Under these critical conditions, delivering supplies becomes an extremely difficult task for the suppliers with limited or nonexistent transportation capacity. Table 1.1 shows the difference between the normal supply chain and emergency supply chain. The design of a reliable emergency supply chain network is hampered by a lack of (1) knowledge about how emergent supply chains operate and interact, (2) methods to coordinate and investigate the flows of both non-priority and priority goods, and (3) scientific methods to analyze logistics systems under extreme conditions. Furthermore, forecasting demand and evaluating the reliability of transportation networks are significant for path selection in emergency logistics management under earthquake and other natural disasters. The reliability of arcs and nodes of a transportation network is time-varying under disaster conditions.

Table 1.1 Comparison between Commercial and emergency supply chains (Tayfur and Benjamin, 2007)

	Commercial Supply Chain	**Humanitarian Relief Chain**
Demand	Predictable.	Unpredictable
Lead Time	Determined by supplier-manufacturer Distribution Center (DC) retailer chain.	Approximately zero.
Distribution Network Configuration	Existing methods for determining the numbers of DCs and fixed locations.	Challenging due to the considerations, and nature of the unknowns.
Inventory Control	Typically: inventory levels based on target customer service levels, demand, and lead time.	Challenging due to high variations in demand locations, demands, and lead times.
Information System	Well-defined, using advanced technology.	Information is often non-existent, or unreliable.
Strategic Goals	Reach higher customer satisfaction and maximize profitability.	Minimize loss of life and improve suffering.
Performance Measurement System	Focus on resource performance metrics, such as minimizing costs or maximizing profit.	Focus on output performance metrics, e.g., ability to meet the needs of the disaster and response time.

The global increase in the number of natural catastrophes highlights the requirement for a better operation and planning of the responding organizations. It is very difficult, if not impossible, to efficiently operate such a complex system without comprehensive mathematical models and forecasting tools.

The existing academic literature is relatively light on disaster management articles that used operations research techniques to deal with the problem. Most humanitarian relief organizations are unable to plan an efficient and effective relief work or prepare for large disaster due to difficulty in accurately guessing the location of disaster. These agencies need to plan for huge surge in demand with a short notice under most difficult scenarios such as damaged roadways and rail lines, chaotic behaviour of victims, breakdown of infrastructure, short lead time and so on. A review of the existing literature indicates that in majority of the situations, the emergency logistics planning and distribution of relief goods from source to the victims take place during post-disaster period (Yi and Kumar, 2007). Shortage of relief goods have been experienced by the donor organizations. In order to develop useful emergency plan and respond to the natural disasters, humanitarian relief organizations, governments and NGOs need to estimate the number of people affected, number of people killed and the economic damages from disasters. Therefore, there is a need to develop a mathematical or probabilistic forecasting tool to predict global annual demand of relief goods. To the best of our knowledge, no work has yet addressed the development of a probabilistic model for the relief agencies' use. This research develops a probabilistic tool to predict the number of natural disasters, bulk economic losses, potential number of victims affected, and the number of people killed and subsequently the demand of certain commodities. The forecasts will be beneficial to the relief organizations, governments and NGOs if they are able to foresee before-hand the demand pattern for the forthcoming years and make emergency logistics plans in advance to handle any possible surge in demand. Knowledge on their current stocks and flows for each type of relief commodities will also aid them in making informed decisions to minimize delay in the arrival of commodities from aid centres and in distribution and rescue effort.

In the business logistics sector in practice, recent natural disasters, such as tsunami in Japan, New Zealand earthquake, Taiwan earthquake, Thailand floods, Queensland floods, and a major fire accident at Nokia's supplier plant in New Mexico, have disrupted the supply of raw materials, parts and finished products in a heavily networked global supply chain. Thailand floods claimed seven major industrial areas and production facilities which manufacture approximately 25% of the world's supply of components for computer hard drives, leading to production delays and disruptions at client businesses. Japan's Sony Corp flagged a record US$6.4 billion loss impacted by the earthquake and flooding. The effects of disruption of manufacturing in Japan had ripple effects in the United States, Europe, Asia and elsewhere and affected the global economy given the interconnectivity of relationships with which many companies manage their supply chain. These disasters demonstrated how vulnerable the networked global supply chain is.

Disaster related supply chain disruptions are increasing across all geographic regions, critically threatening the manufacturing operations across many production facilities worldwide. There is also a direct correlation between disaster-related economic losses and limited investment in risk management (Guha-Sapir et al., 2011b). The reality is that it is too costly to source every component from multiple locations and suppliers throughout the world just to hedge natural catastrophe hazards. This does not mean that companies should turn their back to the supply chain risk problem. The companies have to make their supply chains more robust.

1.2 The importance of this area:

Day et al. (2012) mentioned five reasons why the research in this area is very important. The first reason, OCHA (2008) emphasized that the current method is not enough and that something has to be done to improve the emergency supply chain. Second, the cost in terms of both economic impact and human suffering is still growing. Third, there are many different organizations donating money and resource for the humanitarian / disaster relief event, so we have to find the best way to spend this money (Christian, 2007). The fourth reason, how emergency supply chain systems can be organized to deal with uncertainty. Finally, by studying emergency supply chain we can deal with outcome rather than cost such as time because the time is very important in relief process specially the first 72 hours, also called golden hours.

The issue is that over the previous two decades, outsourcing, globalization, improved cross-border procurement, information technology and shared services centres have encouraged many companies to consolidate facilities and streamline processes by eliminating nonessential and redundant activities and by focusing and automating remaining activities as well. The concepts of total quality management, process-reengineering and six sigma process developments have generated a bias for strong supplier relations and tight connection inside supply chains with the objective of minimizing costs while preserving quality standards. Although companies realize the importance of business operation continuity, it is not uncommon to see in reality that quality, time and cost considerations often win out the trade-off decision over operation continuity considerations, resulting in decisions to decrease inventory levels, have a single-source strategic supplier in any country of the world, adopt just-in-time manufacturing and delivery techniques over higher and safer inventory levels, multiple suppliers and other buffers in the processes. The supply chain disruptions resulting from tsunami in Japan, Thailand floods and Queensland floods illustrate that these trade-off decisions are full of risk. Japan's dominant presence in the global auto and semi-conductor industries resulted in a huge impact across the globe when there were plant shutdowns across Japan. Even the transportation industry was affected to the extent of shipment delays from Japan (PFR, 2011). Thus, there is a need to achieve resilience in networked global supply chains. Along this line, it is also important to articulate why building resilience is necessary and the strategies and actions, which are required by manufacturers, suppliers, distributors, governments and NGO's to achieve resilience and to minimize risks.

Although the literature in logistics management is extensive, the particular problem on the severity of natural disasters in terms of the number of victims and the scale of financial effect, the cost of reaction and rescue related to these events has received little attention. Holguin-Veras et al. (2007) highlighted that after natural disasters, delivering critical supplies becomes a very difficult task due to severe destruction to infrastructures and limited transport capacity. The literature on crisis management in logistics seems to take an idealistic method rather than a more accurate one. For example, most findings are devoted to technological solutions and used a range of optimization methods (Balcik and Beamon, 2008a;Chang et al., 2007;Gao et al., 2010;Yi and Kumar, 2007;Yi and Özdamar, 2007). The impact of supply chain disruptions has been investigated by Hendricks and Singhal (2003). Results of their study of 519 supply chain problem announcements (parts shortages, production problems, ramp-up problems) showed that stock market reactions decrease shareholder value by 10.28%. In a recent survey among Global 1000 companies, supply chain disruptions were the biggest threat to their companies' revenue streams (Green, 2004). Further, Mitroff and Alpaslan (2003) determined a statistic that only between 5% and 25% of the Fortune 500 companies are estimated to be prepared to handle a major supply chain crisis or disruption. They also found that the increasing propensity of companies to outsource processes to global suppliers increases the risk exposure of a supply chain disruption. As the number of "hand-offs" essential to ship goods through multiple checkpoints, multiple ports, and multiple carriers increases, so does the probability of poor communication, human error, and missed shipments. Sheffi (2005) highlighted that the numbers and types of threats potentially undermining a supply chain are now greater than ever, and therefore improving resilience of supply will enhance competitiveness. Resilient enterprises can react to changing market demand ahead of their competitors. Furthermore, Bartos (2012) recently studied the resilience in the Australian food supply chain. The risk that following a natural disaster or major disruptive event, Australians in affected regions would go hungry is growing Bartos (2012). To date the Australian food supply chain has demonstrated a great amount of resilience, but future resilience is decreasing Bartos (2012). Some of the key elements of resilience in the Australian food supply chain are not well understood, which in turn, poses potential threats to the resource of food in the result of a disaster (Bartos, 2012). None of these studies provides an in-depth analysis of resilience influencing characteristics of supply chain networks under vulnerability and natural disasters. Moreover, to our best knowledge, there is no research dealing with these two aspects of emergency and commercial logistics in an integrated manner which is the subject of this study, though such plan can significantly enhance the system-wide operational efficiency. This lack opens up an opportunity for this project.

The outcomes will help manufacturers, suppliers and distributors of raw materials, parts and finished products, and humanitarian relief providers augment their understanding of hazards accumulated from years of improvement without attention to catastrophes and other vulnerabilities.

1.3 Objective and Research question:

- **The objectives of this study:**

A. Develop a forecasting model to predict the economic losses, number of people killed, number of people affected and the number of disasters.
B. Examine the internal structure of the commercial and humanitarian relief supply chains under natural disasters and vulnerability, and develop mathematical models that incorporate various forms of uncertainty into strategic decisions about supply chain design. This will be done by:
    - Determining the probability distributions of uncertain parameters from the last 110 years data available from United Nations and other sources.
C. Develop emergency supply chain model by choosing facility locations to build a resilient supply chain that can face the natural disaster with minimal disruptions, and studying the impact of applying the JIT concept in the emergency situation
D. Reduce the impact of natural disaster in global supply chain.

- **The Research questions of this research :**

1- How can the forecasting improve the emergency supply chain?
2- How will the internal structure of the commercial and humanitarian relief supply chains under natural disasters and vulnerability work?
3- How do the emergency supply chains operate and interact?
4- How can the strategic planning reduce the effect of disaster in the global supply chain?

1.4 Research Methodology

This research passed through three stages:

- The first stage is determination of the probability distributions of uncertain parameters, for example, number of disasters, number of people killed, number of people affected and the economic loss, by using the last 110 years data available from United Nations and other sources. After the distributions are found, a forecasting model is developed for the same parameters. This will help to predict what the government and NGO's need to help and protect people lives' by calculating the amount of relief material they need, and organizing with the suppliers what items they need, the minimum stock, safety stock and how they have to deliver it before and after the disaster happens .
- The second stage using simulation software such as ARENA to develop emergency supply chain model by choosing facility locations to build a resilient supply chain that can face the natural disaster with minimal disruptions and studying the impact of applying the JIT concept in the emergency situation
- The third stage, developing statistical models that incorporate various forms of uncertainty into strategic decisions about supply chain design by using the probability distributions of uncertain parameters is determined from the last 110 years data available from United Nations and other sources.

The activities conducted during this study are shown in Table 1.2 .

Table 1.2 The activities have been conducted during the research

Step No.	Title of Activity	Activity Description & Relation to Research Questions
1	**Literature Review**	Reviewing different type of resources about the topic such as books and journal articles to develop the background about the topic.
2	**Developing the research framework**	This step helps to identify the research framework, objectives and research questions. Furthermore, it gives support and help in organizing the work in the next period.
3	**Starting the data analysis using Statistical software**	Minitab 16 has been used to determine the probability distributions of uncertain parameters. For example, number of disasters, number of people killed, number of people affected and the economic loss, by using the last 110 years data available from United Nations and other sources.

Step No.	Title of Activity	Activity Description & Relation to Research Questions
		
4	**Developing emergency supply chain network using simulation software** 	Develop emergency supply chain model by choosing facility locations to build a resilient supply chain that can face the natural disaster with minimal disruptions and studying the impact of applying the JIT concept in the emergency situation
5	**Examine the internal structure of the commercial and humanitarian relief supply chains**	Developing statistical models that incorporate various forms of uncertainty into strategic decisions about supply chain design.

1.5 Research Scope

The scope of this research is focussed on pre-disaster planning. This has been done by developing a forecasting model to predict the number of victims. Many different tools have been used to predict the uncertain variables such as the number of people affected by using historical data from 1990 and 2011. Firstly, global prediction tools such as time series analysis and forecasting for four random variables, linear regression modelling and next Neuro fuzzy network have been used. This helps the international organizations to be ready for the disaster before it happens. Secondly, country prediction tools such as logistic regression modelling and the decision tree analysis are described. This makes countries deal with the uncertainty of the disaster.

After that an inventory model of emergency logistics has been proposed by introducing three levels of warehouses' network and found the location for these warehouses, and the inventory level has been calculated for each warehouse according to the demand. Next, the proposed model has been examined if the lead time exceed the 72 Golden hours or not by using ARENA software.

The relief materials inventory has been found by using the historical demand data and the UN recommendation for the required relief material per person. After that, the required area to build the camp, which includes the warehouse, typical services and infrastructure requirements have been determined.

The commercial supply chain also get disrupted by the natural disaster. Two different polices to reduce the impact of disaster in the global supply chain have been proposed. First, the trade-offs between supply chain proficiency and catastrophe risk planning have been carefully measured by using decision tree analysis. Secondly, businesses need to be aware that established capacities in disaster resilience and business stability are strong determinations of long-term effectiveness by adding disaster safety stock to the inventory control.

1.6 Organization of the Thesis:

The subsequent chapters are organized as follows:

In Chapter 2, a review of the literature on emergency supply chain is presented .Subsequently , a review of the emergency management is discussed. Finally, the literature of Critical success factors are reviewed.

In Chapter 3, statistical prediction models are presented. In this chapter two levels of forecasting have been used such as global and local prediction models. In the global level many different forecasting tools have been used, for example, time series analysis, linear regressions and Neuro fuzzy network. On the other hand, two different tools have been used to predict local level forecasts such as logistic regressions and decision tree analysis .

In Chapter 4, simulation models are presented. ARENA software has been used to develop the simulation model. The historical data between 1900 and 2012 have been used to calculate the required information to build the model. The simulation models have two stages. The first stage is connected with the demand in the normal supply chain, which includes: if the disaster will happen or not, what type of disaster will happen, where and the demand. Subsequently, the model is validated for the first stage. The second stage in the simulation is supply and distribution of the relief materials to the disaster area within 72 hours. Before the second stage starts, many different variables have been found such as facility locations, the distance between the warehouses and each country in the world and inventory stock level. These components have been used to build the second stage of the model .

In Chapter 5, disaster strategic planning is presented. In this chapter some of critical success factors, such as inventory management, transportation and capacity, site planning and so on have been discussed. The relief material inventory have been found by using the historical demand data and the UN recommendation for the required relief material per person. After that, the required area to build the camp, which includes the warehouse , typical services and infrastructure requirements have been determenied.

In Chapter 6 , methods for reducing the impact of natural disaster in global supply chain have been presented. Two case studies from Japan earthquake and Thailand floods have been presented. The Japanese disaster has a significant influence on four main industries in the world such as car industry and chemicals while Thailand flood has an important effect on two main industries in the world such as electrical part manufacturing and Hard Disk Drives (HDDs).

In Chapter 7 , concludes the findings of the research. The main conclusions and contributions of this research are summarized and possible future extensions are discussed .

CHAPTER 2

Literature Review

2.1 Emergency management

In this chapter, the existing literature related to logistics management in relief operation problem is investigated. Generally, the literature covers a wide range of different applications, approaches and critical success factors. A number of different research articles using percentage of disasters and relief materials demands, distribution and storage of relief materials are also discussed as they are estimated to be of specific importance to this research.

One of the earliest studies for logistics management in relief operations was addressed by Kemball-Cook and Stephenson (1984), for the increasing refugee population in Somalia. Subsequently, Ardekani and Hobeika (1988) addressed the need of logistics management in relief operations for the 1985 Mexico City earthquake. Some specific features of the emergency logistics problem were studied in the routing literature by Aharon et al. (2011), Dror and Trudeau (1989), Gendreau et al. (1999), Golden et al. (1985), Hu (2011), Knott (1987), Kontoravdis and Bard (1995), Min (1989), Nagy and Salhi (2005), and Tatham and Kovács (2010); however, the general logistics problem involving relief supplies distribution characteristics received far less attention. Further, Chang et al. (2003), Chen et al. (2006), Haghani and Oh (1996) and Özdamar et al. (2004) addressed the mathematical formulations for commodities transportation in emergency. Yi and Özdamar (2007) extended the commodity logistics model to integrate the wounded evacuation and emergency medical centre location problems, and the logistics operations are illustrated by a concrete application on earthquake scenario. Further, Yi and Kumar (2007) present a meta-heuristic of Ant Colony Optimization (ACO) for explaining the logistics problem rising in disaster relief activities. The logistics planning includes shipping produces to delivery centres in the affected areas and evacuating the wounded people to medical centres. Furthermore, Balcik and Beamon (2008b) proposed a model to determine the number and location of distribution centres to be used in relief operations.

Humanitarian logistics, also named relief supply chain management, has increased care because of a growing amount of natural and man-made catastrophes and the recognition of the central part of logistics in responding to these (Jahre, 2008). The requests are expected to rise another five-fold over the next fifty years (Thomas and Kopczak, 2005a). However, the works in the area of humanitarian logistics is mainly focused on general procedures and handbooks (Beamon and Kotleba, 2006). Altay and Green III (2006) have reviewed the literature on catastrophe processes management, resulting in only 109 academic articles available in operations management connected journals, representing requests for more research on the subject. The investigative methods used in the field of operations research and management include mainly optimization, simulation and statistics. They concluded that most of the disaster management research was related to social sciences and humanities literature. Kovacs and Spens (2006), and Thomas (2003b) discuss the need for speed and better coordination between those involved in the humanitarian logistics network. Logistics in humanitarian aid operations are highly dynamic, innovative and characterized by difficulty of operational situations and often politically unstable climate, high level of uncertainties in terms of supplies and demand, pressure of time and high staff turnover (Oloruntoba and Gray, 2006a;Wassenhove, 2005). Some studies such as Beamon (2004), Oloruntoba and Gray (2006b), Thomas (2007), Thomas and Kopczak (2005a), Wassenhove (2005), and Ye and Liu (2011), emphasized that some supply chain concepts share similarities to emergency logistics and therefore can be successfully adapted in emergency response logistics. Doocy et al. (2011) discussed the food security and humanitarian assistance among displaced Iraqi populations in Jordan and Syria. In a recent study, Lodree and Jr (2011) highlighted pre-storm emergency supplies inventory planning. More investigation is needed to improve new models or new alternatives of old ones, mainly in preparedness, response and recovery stages of the disaster management.

Although the literature in logistics management is extensive, the particular problem on the reliability of supply chains in emergency logistics planning has received little attention. Zhang et al. (2008) studied the supply chain system reliability based on Markov process for normal business supply chains. Huang evaluated the reliability of railway emergency supply chain in China. Cai and Li (2011) proposed the GO methodology to analyze the transportation network reliability for emergency logistics, Zhang (2012) recently studied the supply chain reliability in emergency situations in China. However, none of these studies provide an in-depth analysis of reliability of supply chains under natural disasters and vulnerability. Scholten et al (2010) conducted planned interviews across five different non-governmental groups to discover what matters these organizations that are facing in their efforts to raise their level of agility. Though agility is understood as a serious ability for such assistance organizations, the pressure from contributors of demonstrating short-term outcomes generates a challenge when the policies needed to reach agility are longstanding in nature. Oloruntoba and Gray (2006b) likewise debate the commercial idea of agility and its relevance in humanitarian relief supply chains. Thomas and Kopczak (2005a) argue the obstacles and challenges that happen in evolving effective corporations in humanitarian relief and disaster aid supply chains. The article analyses the different kinds of corporations that can be formed and prescriptive policies for every kind.

Van Wassenhove (2006) claims that the similar lessons learnt in commercial supply chains can be practical in disaster aid supply chains and humanitarian relief. One such lesson is the issue of preparation. Five dimensions to preparation are defined and debated. Additional significant issue discussed in this article is the power of supply chain partnership. Tan-Mullins, et al. (2007) criticise the events surrounding the December 2004 tsunami that shocked Thailand and nearby countries. They debate that the incident exposed certain interesting developments in humanitarian relief and disaster aid; specifically, aid efforts became extra restricted as current network structures already in place between local groups were able to distribute relief material much more professionally than could the government and relief agencies.

Tatham and Kovács (2010) introduce the idea of “swift trust” in catastrophe aid settings. The phenomenon of “swift trust” takes place in rapidly formed systems where persons and groups rapidly improve a level of trust that in regular situations take much longer to improve. The trust developed in this style is a catalyst and enabler of the partnership required to address the crucial condition at hand.

Martinez et al. (2011) study a multi-group case of huge non-governmental relief organizations (NGO) and emphasise on the controlling of 4X4 light vehicles fleets. These cars are normally used across multiple NGOs for both direction and delivery during catastrophe aid and during growth projects. The investigators highlight that there is much chance for development in the management of these fleets at the nationwide level.

One trend that is detected through the articles reviewed is that disaster aid supply chains and humanitarian relief experience exclusive challenges that are not readily found in normal commercial supply chain. It seems that the inducement aligning tool of commercial gain performs a significant role in commercial supply chains that humanitarian relief and disaster aid supply chains do not enjoy. This poses an exciting challenge for both practitioners and academicians: how to drive the suitable cooperative performance and investments in a supply chain where profits and economics are not a driving force of cohesion.

Day et al. (2012) mentioned five reasons why the research in this area is very important. The first reason, OCHA (2008) emphasized that the current method is not enough and that something has to be done to improve the emergency supply chain. Second, the cost in terms of both economic impact and human suffering is still growing. Third, there are many different organizations donating money and resource for the humanitarian / disaster relief event, so we have to find the best way to spend this money (Christian, 2007). The fourth reason, how emergency supply chain systems can be organized to deal with uncertainty. Finally, by studying emergency supply chain we can deal with outcome rather than cost such as time because the time is very important in relief process specially the first 72 hours.

For years, Operations Research methods have been used to a huge variety of problems to define the best geographical locations for facilities (Hale and Moberg, 2003;Klose and Drexl, 2005;Owen and Daskin, 1998;ReVelle and Eiselt, 2005) for new surveys on facility location research. Facility location problems develop their importance from two reasons: their direct effect on the system's timeliness of response to the demand and functional cost (Haghani, 1996). While the objective of facility location models addressing commercial sector problems is commonly to maximize profit or reduce cost, the models addressing community and emergency services instead focus on response time and user accessibility (Marianov et al., 1995;ReVelle et al., 1977).

Since disasters such as floods, tsunami and hurricane, and so on may happen anytime around the world, disaster management has developed as a worldwide theme. There is a growing attention in emergency management, aid chains and catastrophe response in recent years. According to Drabek and Hoetmer (1991), crisis management is the profession and discipline of applying technology, planning, science and management to contract with dangerous events that can create wide damage. Emergency management is often conceptualized as a difficult multi-objective optimization concerning how to explain the disaster situation with narrow resources. Sheu (2007) pointed out efficient logistics play a significant part in relieving the influence of catastrophes. Liu (2004) suggested an agent-based supply detection construction to search for applicable aid resources on the Internet. Li and Tang (2008) recognized an artificial disaster logistics planning structure (Aelps) to describe the basic elements of emergency system using a complicated computer platform. Yi and Özdamar (2007) established a dynamic logistics model considering both the evacuation of the injured and the supply of relief demands. It is clear that the existing literatures mostly deal with a specific activity in the emergency response process. Researchers care more about emergency logistics, such as forecasting, evacuation and distribution, establishing multi-objective optimization model and to solve related problems (Fiedrich et al., 2000;Hwang, 1999;Nisha De Silva, 2001;Özdamar et al., 2004). Taking into consideration of post-disaster activities, Costella et al. (2009) suggested a technique to assess safety and health management system and studied the resilience of emergency. Others build relief systems to help the management of emergency reaction. But none of them study the emergency management matter from a complex viewpoint. So how to efficiently develop the emergency management using narrow resources in an organized way, standing at the managers' idea of view, requests more care and additional study. To challenge the emergency management, emergency disasters essentials need to be developed along with the conditions influencing the management.

2.2 Critical Success Factors (CSF)

From the above discussion it appears apparent that, as with profitable supply chains, there are significant main reasons which will control the ultimate achievement of HA delivery. As an effect to the argument on SCM for HA, this study therefore looked to categorize the range of factors which are serious for the effective process of an HA supply chain and applied Critical Success Factors (CSF) to humanitarian relief area based on a theoretical argument and historical data. Such factors are transport and capacity planning, information management, inventory management, strategic planning and technology utilization, human resource management, and continuous improvement and collaboration. Such causes are normally mentioned in the literature as CSFs. CSFs are ”the features, variables or situations that when properly sustained, managed or maintained can have an important influence on the achievement of a company in a specific industry” (Korpela and Tuominen, 1996). The first phase in this study has therefore been to classify, from the literature, CSFs significant within commercial supply chain management and to evaluate their consequence to HA supply chains.

The idea of success factors was first established by Daniel (1961), the simple idea being that if confident factors, critical to the success of that organisation, are not reached the organisation will fail. Rockart (1979) explains CSFs as those a few important areas of action in which satisfactory results are totally essential for a certain company to reach its aims. CSFs are the variables, conditions or characteristics that must happen right to have a main effect on the success of an organization. Furthermore, Thierauf (1982) states that if the effects in these areas are not satisfied, the organization’s efforts for the period will be less than wanted. When CSFs are sufficiently applied, they will encourage and guarantee the improvement of an organization. If not, they may also cause the failure of the organization. So, for understandable causes, CSFs must receive due care from the viewpoint of management. According to Freund (1988), it is better to classify CSFs from the upper level of the organization, in order to guarantee that the CSFs of junior level are reliable with the general CSFs. He further recommended that there should not be too many CSFs. If too many CSFs are recognized, these CSFs are perhaps defined at a too complete level, which will simply root difficulty in practice and misunderstanding. Consequently, CSFs categorizing method should be carried out at different levels such as department, organization, and even the specific activity level.

Further, Rockart (1979) extended the theory based on work started at MIT, recognising, where pertinent, good delivery as a factor (Huotari and Wilson, 2001). Porter (1985) later joined CSFs with the value chain model. A number of authors have considered the part of CSFs inside profitable supply chains. Gunasekaran and Ngai (2003) defined five important roles critical to a small logistics business, being strategic planning, capacity planning, information management, transportation planning, and inventory management. Power et al. (2001) considered success factors in nimble supply chains and identified seven independent variable sets being Participative Management (Human Resource Management (HRM)), Resource Management (Inventory Management), Supplier Relations (Collaboration), Computer Based Technology (Information Management), Just inTime Methodology and Technology Utilisation and Continuous Improvement. It is also probable that separate CSFs may have their individual exact CSFs. Consequently, Razzaque and Sheng (1998) isolate CSFs specific to outsourcing, which it controlled inside strategic planning. The above reasons are now considered below.

When it comes to management, it is strongly evident from the literature that CSFs can be investigated and studied at the industry level, company level, and even the wider socio-political and economic level. Razzaque and Sheng (1998) extended the logic and idea of CSFs to the supply chain, and examined CSFs of outsourcing logistics role, where essentials such as performance monitoring, knowing the payback period, setting of standards, communication and development of relations are considered of great importance. Generally, there are many CSFs recognized previously in the literature related to supply chain management. Moreover, these CSFs under the commercial environment may be applicable to the efficacy and achievement of emergency management, but additional and deeper research in the area of emergency management is still necessary.

CSFs have been extensively used in the commercial situation, but infrequently practical in the disaster and crisis management area. Through a detailed literature review in CSFs research in commercial context, Pettit and Beresford (2009) applied CSFs to humanitarian relief area based on a theoretical argument. Elements such as transport and capacity planning, strategic planning, inventory management, human resource management, information management and technology utilization, and continuous improvement and collaboration which are CSFs resulting from normal supply chains are argued under humanitarian relief condition. Oloruntoba (2009) analyzed CSFs of the Hurricane Larry disaster aid chain based on document analysis and semi-structured argument with catastrophe managers. He identified CSFs of the readiness and planning stage and result response phase. Five aspects, government unity, specific early warnings, participation of military unit, education campaigns and routine disaster awareness, and prior standing planning, are mentioned as CSFs in the Hurricane Larry emergency aid chain.

Some other literature on disaster management do not contain CSFs as a significant issue, but they do include principles, or influences that have a great impression on the achievement of aid management success (Pettit and Beresford, 2009). So an evaluation of literatures connected to emergency rules, elements or strategies is necessarily taken to find out probable CSFs. Cook (1984) highlighted 10 components in aid logistics and summarized them as guidelines. Oloruntoba (2005) discussed plans NGOs adopted to guarantee the success and effectiveness in the 2004 tsunami reaction. Kovács and Spens (2007) generated an outline distinguishing between aid processes of emergency management, and pointed out some factors that managers should seriously consider before and after disaster.

All these elements, strategies, or guidelines can be seen as critical success factors; however, these are not defending factors as CSFs. Commonly speaking, in all literatures information technology utilization and information management in disaster is considered as a very significant component. Long (1997) specified that communication technology chooses the success of the saving operation. To simplify communication information systems, information management and transition and decision support systems are of great significance (Pettit and Beresford, 2009). Power (2005) stated that we should make complete use of DSS in disaster condition. Also, as an effective method to develop the aid chain, use of novel technologies can have a good influence on emergency aid (Power et al., 2001). To make complete use of technology, providing well-trained aid and logistics specialists will significantly develop the efficacy of rescue response (Perry, 2007;Thomas, 2003b). Furthermore, the method in which the aid operates will influence on their skill to allocate relief aid (Thomas and Kopczak, 2005a). Oloruntoba (2005) pointed out that coordination of relief reaction and logistics are the bottlenecks in emergency relief. That is, guideline of collaboration should be made to guarantee the operation and communication between different departments, local government and the military. Moreover, studying and updating emergency strategy dynamically is very significant for the full tool of emergency aid operation. While numerous investigators emphasise only on short-term aid, ignoring long-term reconstruction effort Gustavsson (2003) and Choularton (2001) highlighted the significance of learning from catastrophes, and addressed problems related to learning and danger migration. Thus, preparation plan should be studied to include lessons learnt and the experience from the present disaster (Thomas, 2003b). Similar continuous improvement, commercial supply chains and collaboration are dynamic for disaster management (Beamon, 2004;de Brito et al., 2007;Van Wassenhove, 2006). It is essential to assess the effectiveness of rescue process to further develop it.

Subsequently, factors influencing the disaster emergency management are collected through wide literature criticism. Table 2.1 summarizes the elements resulting from related literatures. CSFs in emergency management are dynamic basics for a specific disaster reaction. They are crucial for a successful aid action, and they directly contribute to get success. That is, they are the important causes of failure or success of an exact management action. If these CSFs are not acceptable, the aid response will fail to influence those who require it, or fail to distribute proper items to correct places at suitable time. Thus, identification of CSFs is pretty significant, allowing disaster managers train specialized aid labors, develop new problem-solving capabilities and accept advanced technology, and to apply all of them in real life.

Table 2.1: CSFs literature review summary

Factors	Source	Advantage	Disadvantage
Well-planned disaster aid supply system	(Davidson, 2006), (Cook, 1984), (Pettit and Beresford, 2009)	Reduces the relief operation response time, decreases the amount of relief material wasted.	Perishable items' loss when there are no disasters.
Realistic structural organization and clear awareness of tasks	(Davidson, 2006), (Nisha De Silva, 2001), (Oloruntoba, 2005)	The tasks are done with a high level of quality, less time, cost and number of injuries in the rescue teams.	Coordination of international rescue teams is a difficult task.
Valid disaster reaction plan and rules	(Afedzie and McEntire, 2010), (Oloruntoba, 2005), (Özdamar et al., 2004)	The tasks are done with a high level of quality, less time, and cost	
Financial guaranteeing measures and previous preparation of logistic centres and shelters	(Afedzie and McEntire, 2010), (Davidson, 2006), (Pettit and Beresford, 2009)	Reduces the relief operation response time, decreases the amount of relief material wasted.	
Instruction operation on catastrophe response and prevention	(Oloruntoba, 2009), (Pettit and Beresford, 2009), (ter Mors et al., 2005)		
Detailed training of specialists such as medical staff and rescue workers	(Oloruntoba, 2009)	The tasks done with a high level of quality, less time, cost and number of injuries in the rescue teams.	
Robust capability to send out exact early caution about probable dangers	(Oloruntoba, 2009), (Pettit and Beresford, 2009)	Reduces the number of people suffering.	
Regular organization of simulated catastrophe application	(Oloruntoba, 2009)	The particular advantage of simulation as a source of lessons is that it puts forward many aspects of what people prefer not to think about in their everyday working life	

		situation: an accident.	
Very short reaction time to start the relief plan	(Davidson, 2006)	Increases the probability to find people life and reduce the people suffering.	Increases the operation cost and over supply for the relief materials.
Government unity of management to plan and organize	(Davidson, 2006), (Cook, 1984), (Oloruntoba, 2005), (Pedro et al., 2005), (Pettit and Beresford, 2009)	Decreases the amount of relief material wasted.	Increases the operation time and may affect the quality of the work.
The support and involvement of army	(Davidson, 2006), (Özdamar et al., 2004), (Pettit and Beresford, 2009)	Increases the number of relief teams. This leads to reducing the responses time, increasing the probability to find people life and reduce the people suffering.	Increases the injuries probabilities occurs for the rescue teams.
Appropriate and correct aid needs assessment	Hoda et al. (2010), (King, 2005), (Maxwell and Watkins, 2003), (Nisha De Silva, 2001)	Gives an appropriate aid assistant and increases the number of people recurs.	
The security of aid reliefs through transportation and distribution	(Pettit and Beresford, 2009), (Power, 2005)		
Clear technique of reporting and submitting data	(Oloruntoba, 2005;Oloruntoba, 2009), (Thomas and Kopczak, 2005b)	Reduces the relief operation response time, decreases the amount of relief material wasted. Increases the probability to find people life and reduce the people suffering.	
Operative emergency information structure to ensure data moving	Oloruntoba (2005);Oloruntoba (2009), (Pettit and Beresford, 2005)	The tasks are done with a high level of quality, less time, and cost. Reduces the people suffering.	
Application of current logistics skill	(Long and Wood, 1995), (Pettit and Beresford, 2009)		
Reconstruction and staff comforting	(Gustavsson, 2003), (Kovács and Spens, 2007), (Opricovic and Tzeng, 2002),		

	(Thomas, 2003a)		
Statistics and criticism of damage data	(Davidson, 2006)	Increases the awareness about this problem.	
Assessment on the effectiveness and efficiency of the management method	(Barbarosoglu et al., 2002), (Davidson, 2006), (de Brito et al., 2007), (Poister, 2003), (Van Wassenhove, 2006)	Improves the relief operation by finding the weakness points and solved them.	If the assessment done in a wrong way this may have bad effect on the relief operation.
Continuous development of the functioning system of disaster	(Afedzie and McEntire, 2010), (Kovács and Spens, 2007), (Thomas, 2003a)	Improves the relief operation by finding the weakness points and solved them.	
Long-term planning, management , decision making and leadership	(Gunasekaran and Ngai, 2003), (Razzaque and Sheng, 1998), and Wong (2005)	Increases the awareness about disaster. Improve the organization, reduce the relief operation response time and decrease the amount of relief material wasted.	
Inventory controlling	(Gunasekaran and Ngai, 2003), (Power et al., 2001), Wong (2005), Whybark (2007), and (Beamon and Kotleba, 2006)	Decreases the amount of relief material wasted by controlling the relief materials were sent to the disaster area.	
Transport restraints and availability	(Gunasekaran and Ngai, 2003)		
Transport capacity Storage, and processing	(Gunasekaran and Ngai, 2003)	Reduces the relief operation response time.	Increases the cost and waste of materials.
Strategic data management and enterprise supply planning(ERP)	(Power et al., 2001), (Huotari and Wilson, 2001), Wong (2005), and Umble et al.(2003)	Decreases the amount of relief material wasted by controlling the relief materials were sent to the disaster area. An ERP system offers the decision makers the means of enhancing the knowledge about the process that in turn helps to make reliable decisions more rapidly and as well collecting sources to support their decisions. It also helps managers to handle more larger and complex	ERP integration of its system that is the basic problem in its implementation and ERP won't be able to make decision by itself. ERP focuses on production level and therefore they have a weak

		problems.	analyzation.
Application of novel technology	(Power et al., 2001) and (Gooley 1999)	Improves the relief operation	The cost will be very high
Participative administration	(Power et al., 2001) and Wong (2005)	High level of quality, less time, and cost.	Increased participation led to decision-making process slows down
Benchmarking, key performance pointers	(Power et al., 2001), (Korpela and Tuominen, 1996), Wong (2005), and (de Brito et al., 2007)	Improves the relief operation by finding the weakness points and solved them.	If the choosing of benchmark done in a wrong way, this may have bad effect on the relief operation.
Supplier relations and Partnership	(Power et al., 2001), (Soin, 2004), (Cottrill, 2004), and (Gooley 1999)	Reduces the relief operation response time and increase efficiency	Hard to obtain, costly in terms of time and effort.
lean supply, agility, and Just-in-time	(Power et al., 2001),(Christopher and Towill, 2001), and (Mason-Jones et al., 1999)	Reduces the relief operation response time	JIT requires significant coordination between retailers and suppliers in the distribution channel.

2.3 Reliability of supply chains

Disasters have influenced infrastructure, hence the network reliability decreased during the emergency distribution. Network reliability was a critical issue to determine the efficiency during relief goods distribution.

Several researchers applied network reliability to measure the performance. Lida (1999) pointed out that the network reliability would be influenced by the congestion and capacity and suggested two indices to estimate the reliability of links. Two indices, including connectivity reliability and travel time reliability, were recommended. Basic analysis of reliability was illustrated in normal and abnormal conditions.

Chen et al. (2007) applied three measures to quantify the travel time reliability during different time periods. They were the coefficient of variations (CV), the planning rate index (PRI), and the probability indicator (PI). The temporal distribution characteristics of the travel time reliability were analyzed and the data were from taxis in Beijing. The results showed the reliability was high during the off-peak hours and was low during the peak hours.

Knoop et al. (2007) used a traffic simulator to study the consequences of the blocking on a link. The proposed simulator considered the effects of spillback. Spillback and nonspillback cases were also evaluated for vulnerable links. The results showed that spillback should be included in identifying vulnerable links. If a freeway link was damaged, the network performance dropped.

Chen et al. (2008) indicated the performance measures need to be developed for assessment of network reliability under flooding, earthquake and hurricane. The major performance measures included travel time and capacity reliability.

Jing and Mahmassani (2011) proposed a stochastic model to predict the travel time variability. Breakdown was assumed to be a factor to influence the flow at a random time period. Monte Carlo simulation was applied to demonstrate the travel time reliability model.

The typhoon and heavy precipitations affected the infrastructure in Taiwan. In 2009, Taiwan was hit by Typhoon Morakot, and it caused a serious flooding. The flooding deteriorated the infrastructure and caused large number of road closures.

In summary, adverse weather deteriorated the traffic conditions and traffic parameters such as travel time, delay, speed and safety of drivers. Thus, the issue of network reliability assessment measures needs to be considered during the process of relief distribution.

2.4 Emergency Simulation for disasters management:

According to (James, 1969), a disaster is an event happening suddenly and creating great loss of life, suffering or injury. Likewise the Merriam-Webster describes the disaster as a unpredicted catastrophic happening getting great loss, or damage destruction. As a matter of circumstance, disasters are sudden actions such as accidents ,flood , hurricanes , earthquake, fires, and so on, that bring unidentified situations. Recently, natural disasters have hit different countries. Such as Thiland flood, Japan earthquake , the 9/11 terrorist attack in USA, and Hurricanes such as Katrina are some of the most significant catastrophes that have affected huge damages in terms of both infrastructures and systems such as transportations, telecommunications and lives of people.

Reduction of economic damages and people’s life losses are the key drivers for developing methods able to model correctly a disaster situation and improve the management of the important emergency facilities. These tools are usually created on Modeling and Simulation and are used at different modalities and levels both for personnel preparation and for the estimate of the effect of the disaster.

Ontology is a suitable method for an official illustration of a catastrophe. An instance of ontology for representing disasters and their effects and for improving simulations' ability to come up with more perfect plans for emergency conditions in disasters mitigation is suggested by Joshi et al. (2007). They proposed method to model disaster areas which is built on a Web Ontology Language (OWL).

Official representations of disasters are the first phases toward the development of decision support tools to be used for approximating the effect of different types of disasters and justifying their effects both in terms of damages to various infrastructures and human life losses. However, as pointed out by Dudenhoeffer et al. (2007), an additional characteristic to be essentially considered for disasters management and effects mitigation is the right understanding of the vulnerabilities and interdependency to the critical portions of serious infrastructures or processes. Interdependency and vulnerability of serious infrastructures in specific supply chains in terms of resilience or ability to rapidly respond to unexpected and catastrophic events is also presented in Longo and Oren (2008).

Kanala et al. (2008) presented a model of web-based tool based on M&S to be used by responders for emergency services preparation and condition analysis. Guimarans et al. (2006) highlighted their responsiveness on the management and planning of the three core emergency facilities (Police service, Fire service and Medical service) in road accidents. They propose a software structure based on simulation and cooperative with optimization techniques for the design of real-time result support tools to be used for the management of the emergency services. Along with optimization procedures, simulation is regularly used in planning with gaming technology; the mixing of simulation and gaming can successfully provide disasters management.

Bruzzone et al. (2006) validate the capacities of M&S as a support method for assessing the influence of huge disasters such as Japan tsunami, Thiland flood, Katrina hurricane on transportation schemes in a huge area. They conduct selected initial study to connect the alert level to the time demanded by migrants to reach their target (definite as readiness). Arslan (2009) defines the use of a Tactic Nuclear Biological Chemical Attack Simulation (TNBCAS) software keen to simulate nuclear, biological and chemical (NBC) propagation and contamination inside a typical NBC attack situation with respect to the geographical features and atmospheric situations. He offers a brief explanation of the simulation software capacities.

Finally, the serious part played by Geographic Information Systems (GIS) in developing tools for catastrophe management is noted. They are presently used as sustenance tools, for several purposes such as resources mapping, various information sources and distribution, logistics planning, and so on, and in different kinds of disasters. To cite just limited works as application cases, Al-Hanbali et al. (2006) and Chang and Hsueh (2007) use GIS system for two different aim. Al-Hanbali et al. (2006) improve a GIS collective with a Hospital Mapping Software both to analyse the real hospital spreading in Amman city (in order to develop service coverage) and to offer users for the most shared functionalities of GIS databases. Chang and Hsueh (2007) improved a GIS able to evaluate rescue request in case of flood disaster and deliver the victims with the information about rescue supply.

2.5 Small Scale and Large Scale Evacuation Simulation Models

The essential for large scale evacuation is generally due to emergencies that involve civilians in case of announced or happened disasters. A criticism of methods used in current large-scale simulation evacuation simulations and decision support systems is given by Pham et al. (2008). They review 11 models following their first publication. Further information of model studied in Pham et al. (2008) are described in Table 4.1. In addition to the evacuation models suggested in Table 4.1, a number of study concepts have been suggested; most of them suggest a M&S based methodology and deal with preparation problems, evaluation of evacuation time and evacuation mechanism and management. Dixit and Radwan (2008) deal with the optimal planning problems for evacuation orders.

Table 2.2: – A summary of the evacuation models reviewed in Pham et al. (2008)

Model Name	Usage	Authors
NETVAC1	Network Disaster Evacuation model based on a simulant skilled of approximating traffic decorations and evacuation time on road network nearby nuclear power plants	(Sheffi et al., 1982).
CLEAR	Analyzes Logical Evacuation and Reaction model is based on a microscopic simulant for assessing network evacuation time during a nuclear disaster	(Mclean et al., 1983)
NESSY-IV	Net Structure Analyzing System IV model based on a macroscopic simulant is appropriate for small region and works correctly for earthquake disasters	(Hiramatsu, 1983)
I-DYNEV	Cooperative Dynamic System Evacuation model is used for disaster evacuation and planning in situation of nuclear power plant events	(Lieberman and B. J., 1980)
MASSVAC	Mass Evacuation model is a simulation device for the analysis and assessment of urban area evacuation policies.	(Hobeika and B, 1985) (Hobeika et al., 1994)
TEVACS	Transportation Evacuation System model is used for disaster supervision and evacuation is case of nuclear events.	(Han, 1990)

REMS	Regional Evacuation Modeling System model is a choice support device generally used for transportation management and control in case of disasters	(Tufekci and T.M., 1991)
TEDSS	Transportation Evacuation Decision Support System is based on MASSVAC system and used for traffic management and evaluation of evacuation phase for nuclear power plants in Virginia	(Hobeika et al., 1994)
OREMS	Oak Ridge Evacuation Modeling System is used for disaster management in huge scale evacuation method and participates a fortran based simulant.	(Rathi and R.S., 1993); (Rathi, 1994)
CEMPS	Configurable Emergency Management and Planning System syndicates a disconnected event simulation system .	(Pidd et al., 1996)
D4S2	Dynamic Disconnected Disaster Decision Simulation System syndicate san ARENA simulation model with SQLServer database and a GIS to simulate evacuation procedure and properties distribution.	(Wu et al., 2007)

A real time decision support system based on optimization algorithms and simulation has verified to be a useful tool to develop evacuation operation efficiency. Russo and Vitetta (2008) aim at building a prototype laboratory system of models for community administration where evacuation models and actions can be applied. Such a prototype will offer public management with rules for preparation and handling evacuation in a city system under emergency situations. Oleson and Kaup (2006) debate a common technique for applying a crowd based social potential prototypical. The technique is based on the accomplishment of the following six phases: expectations, environment, forces, model choice, influences and force weights, and summarises a set of strategies for building and testing new community potential models along with adjustments to current models.

Kaup et al. (2006) present a simulation prototypical for disaster planning and crowd management purposes. Specifically, the model goals at simulating crowd performance under both non-panic and panic situations both in an unconstrained and constrained environment.

Perumalla and Beckerman (2007) suggest an analysis method to large-scale vehicular system simulations. They first improve an analysis method that could be used to explain the problem of presenting functioning metrics to the decision makers and to track the modification of simulation consequence quality through multiple runs and then apply this procedure to the evacuation occurrence by developing simplified simulations and detecting the evacuation time distributions.

Small measure evacuations mostly refer to the evacuation of people and goods from small areas such as buildings in case of emergency due to fires, bombs, and so on. Needless to say, as in the situation of large scale evacuation simulations, most of the suggested approaches are based on M&S ,also joint with optimization algorithms and purpose at improving the evacuation efficiency in terms of evacuation times, valuation and study of evacuation plans, path/routes optimization. Specific revisions also emphasis on human performance during evacuation. In the consequence, some of the study works presented at the Emergency Simulation Track (part of the SCSC) are briefly defined.

Filippoupolitis et al. (2008) discuss the building evacuation optimization problem thru developing an agent-oriented Distributed Building Evacuation Simulator (DBES). The DBES is joined with a wireless device network which proposes a closed loop representation of the evacuation process, counting the emergency decision making and the sensed data.

Su et al. (2008) improve a discrete-event computer simulation prototypical for evaluating evacuation programs and offer a comprehensive hint of evacuation plans for hospital buildings in the event of a probable bomb threat.

Filippoupolitis and Gelenbe (2009) develop a decision support method for catastrophe management in buildings. They suggest the use of a system that offers movement decision support to evacuees by leading them through the shortest or less dangerous ways to the exit. Furthermore, Ekizoglu (2009) improves and uses a Simulex simulation for examining the emergency evacuation problem within the Istanbul Technical University. Some evacuation situations have been verified and matched in terms of evacuation times.

Kobes et al. (2009) address the probability using virtual authenticity for reviewing human performance in fires. In precise, they improve an investigation tool (BART, Behavioral Assessment and Research Tool) whose core aim is to produce the data that fire safety engineers necessitate for the design of a safe building that fulfills with real human performance in fires.

As can be seen from the review that most of the studies focus on the evacuations process and they ignore the impact of shortage of relief materials on victums’ health. Thus, the lead time needed to distribute the relief material has been studied in this model .

2.6 The research gaps

After a critical literature review has been completed, the research gaps have been identified. The following gapss have been considered in this study:

1. There are no forecasting models to perdict number of people affected by the disaster, economic losses, and number of people killed in the literature.
2. The majority of the previous studies focus on the national emergency supply chain rather than studying the global emergency supply chain.
3. Most of the simulation studies focus on the evacuations process and they ignore the impact of shortage of relief materials on victums’ health and the lead time needed to distribute the relief materials to victims of disaster.

4. None of the previous research focuses on how to reduce the impact of natural disaster in the global supply chain.

2.7 Summary

This chapter reviewed the body of knowledge relative to reliability of supply chain in emergency logistics. It also included the application of critical success factors to HA area as a methodology applicable to disaster and crises management. The following Table 2.2 illustrates the references used in the various barts of this research study.

Table 2.3 : Summary of literature Review .

Authors	Disaster prediction tools	reaction time	Facility location	decision making	Plan evaluation	Disaster evacuating simulation	Disaster relief simulation	Site planning	Warehouse capacity	transport capacity	Inventory controlling	Long-term planning	Well-planned disaster aid supply system	Statistics and criticism of damage data	lean supply, agility, and Just-in-time	3 level of Inventory	Supplier relations and Partnership	Impact of disaster on global supply chain
Davidson		√			√								√	√				
Cook													√					
Pettit and Beresford													√					
Nisha De Silva										√								
Oloruntoba							√	√										
Afedzie and McEntire								√										
Özdamar et al								√										
ter Mors								√										
Pedro et al																		
Hoda et al								√										
King								√										
Maxwell and Watkins								√										
Power								√										
Thomas and Kopczak						√						√						
Van Wassenhove					√													
Poister					√													

de Brito et al.,					√													
Barbarosoglu et al.					√													
Gunasekaran and Ngai				√						√	√	√						
Razzaque and Sheng				√								√						
Wong				√							√	√		√				
Power et al											√			√	√		√	
Whybark											√							
Beamon and Kotleba,											√							
Huotari and Wilson,														√				
Umble et al														√				
Christopher and Towill															√			
Mason-Jones et al															√			
Soin																	√	
Cottrill																	√	
Gooley																	√	
Lodree and Jr											√	√						
Kovacs and Spens	√																	
Thomas	√																	
Yi and Kumar						√												
Sheffi et al.,						√												
Mclean et al						√												
Hiramatsu						√												
Lieberman and B. J.						√												
Hobeika and B,						√												
Han						√												
Tufekci and T.M						√												
Hobeika et al.						√												
Rathi and R.S						√												
Rathi						√												
Pidd et al						√												
Wu et al						√												
Abu Nahleh et al.	√	√	√	√	√		√	√			√	√	√	√	√	√	√	√

CHAPTER 3

Statistical Prediction Model

3.1 Introduction :

Uncertainty in the demand and the location of the disaster makes the emergency supply chain very complex. So in order to improve it the uncertain variables should be predicted by using some statistical models. Most humanitarian relief organizations are unable to plan an efficient and effective relief work or prepare for large disaster due to difficulty in accurately guessing the location of a disaster. These agencies need to plan for huge surge in demand with a short notice under most difficult scenarios such as damaged roadways and rail lines, chaotic behaviour of victims, breakdown of infrastructure, short lead time and so on. A review of the current literature shows that in most of the situations, the emergency logistics planning and distribution of relief goods from source to the victims take place during post-disaster period (Yi and Kumar, 2007). Shortage of relief goods have been experienced by the donor organizations. In order to develop useful emergency plan and respond to the natural disasters, humanitarian relief organizations, governments and NGOs need to estimate the number of people affected, number of people killed and the economic damages from disasters. Therefore, there is a need to develop a mathematical or probabilistic forecasting tool to predict global annual demand of relief goods. To the best of our knowledge no work has yet addressed the development of a probabilistic model for the relief agencies' use. This research develops a probabilistic tool to predict the number of natural disasters, bulk economic losses, potential number of victims affected, and the number of people killed and subsequently the demand of certain commodities. The forecasts will be beneficial to the relief organizations, governments and NGOs if they are able to foresee before-hand the demand pattern for the forthcoming years and make emergency logistics plans in advance to handle any possible surge in demand. Knowledge on their current stocks and flows for each type of relief commodities will also aid them in making informed decisions to minimize delay in the arrival of commodities from aid centres and distribution and rescue effort.

In this chapter many different tools have been used to predict the uncertain variables by using historical data from 1990 and 2011.This chapter includes first global prediction tools such as time series analysis and forecasting for four variables, linear regression modelling and next Neuro fuzzy network. Secondly, country prediction tools such as logistic regression modelling and the decision tree analysis are described .

3.2 Global prediction tools:

3.2.1 Time series analysis and forecasting:

There are several common theoretical statistical distributions which may be used to model the number of natural disasters, economic losses, number of people affected, and number of people killed over time. It has been found that a relatively small number of statistical distributions satisfy most needs in emergency logistics planning. The individual distribution used is subject to the nature of the data, in each case.

The probability distribution of a random variable may be defined empirically or through one of many well-known probability distributions. In many cases the analyst may fail in an attempt to describe the behaviour of a random variable through a well-known distribution and thus be forced to use an empirically derived probability distribution. However, where the behaviour of the random variable can be adequately characterized by a well-known probability distribution it will be convenient and useful to do so. In this paper, are presented the properties of relevant well known random variables and their probability distributions.

Exponential Distribution

This is probably the most important distribution in engineering and lifetime work [Reliability, Handbook]. It has the advantages of a single, easily estimated parameter (λ), mathematically very tractable, and fairly wide applicability.

The probability density function is (Christian, 2007)

$$f(t) = \lambda e^{-\lambda t} \qquad \text{for } t > 0, \qquad (3.1)$$

where λ is the parameter.

Weibull Distribution

The Weibull random variable finds its most frequent application in engineering. It is a general distribution and by adjustment of the distribution parameters, it can be made to model a wide range of the distribution characteristics.

The probability density function of a two parameter Weibull distribution is (Christian, 2007)

$$f(t) = \alpha\beta\, t^{\beta-1}\exp(-\alpha t^{\beta}), \qquad t \geq 0,\ \alpha > 0,\ \beta > 0. \qquad (3.2)$$

where β is referred to as a shape parameter and α a scale parameter.

There are several methods by which one can obtain good point estimates of the unknown parameters, α and β of the two parameter Weibull distribution. The methods include the iterative solution of the maximum-likelihood equations, moment estimators, and several types of linear estimation techniques. A discussion of these methods is presented in Kumar (1988).

Data has been collected from the Centre for Research on the Epidemiology of Disasters (CRED)'s EM-DAT worldwide database for natural disasters. This has been sponsored by the United States Agency for International Development's Office of Foreign Disaster Assistance (USAID/OFDA). It contains data from year 1900 to 2011. CRED has compiled the data from numerous sources including UN agencies, NGOs, insurance companies and research institutes (Guha-Sapir et al., 2011b). Systematic collection and study of these data provides invaluable information to relief agencies and governments in duty of relief and recovery actions. EM-DAT provides an objective basis for vulnerability valuation and rational decision-making in catastrophe conditions. In addition to providing data on the human effect of disasters, for example the number of people killed, injured or affected, EM-DAT provides disaster-related economic damage estimates and disaster-specific international aid contributions.

Minitab Statistical Software's built-in "trend analysis plot" option has been used, where one can add trend lines to data sets (from year 1900 to 2011 for different variables) after the charts have been generated. Figures 3.1 thru 3.3 illustrate the charts and trend lines. Subsequently, Minitab's Individual Distribution Identification tool has been used to find the distribution of data. The tool generates probability plot and assesses the fit. A given distribution is a good fit if the plotted points roughly follow a straight line and the goodness of fit test p-value is greater than 0.05 for an alpha level of 5% or confidence interval of 95%. The tool allows to easily compare how well the data fit 16 different probability distributions. There are three measures generated in the output: Anderson-Darling statistic "AD", p-value and 'LRT P'; and all three have been considered while identifying the best fit distribution. Lower AD values indicate a better fit. It is generally valid to compare AD values between different distributions and go with the lowest. Additionally, a high p-value is required. A low p-value (< 0.05) indicates that the data do not follow that distribution. Moreover, for 3-parameter distributions only, a low 'LRT P' value indicates that adding the third parameter is a significant improvement over the 2-parameter version. A higher value of 'LRT P' suggests that one should stick with the 2-parameter version.

After identifying the best fit probability distribution for each data set, estimates of distribution parameters are read from the Minitab output. Subsequently, the probability distribution function is used to calculate the values of the variables of interest for future periods such as year 2012 thru 2016. Relief agencies need to know the future aggregate demand of relief goods much in advance to plan for supply and distribution. Figure 3.1 illustrates the number of disasters reported from year 1900 to 2011. The trend indicates that the number of disasters is exponentially increasing with respect to time. Identifying the best fit curve indicates that the aggregate number of natural disasters is Weibull distributed with shape and scale parameters values as 0.6548 and 126.6.

Figure 3.2 shows the aggregate number of people affected globally due to natural disasters from year 1900 to 2011. Moreover, this trend also indicates that the number of people affected is exponentially increasing with respect to time. Identifying the best fit curve indicates that the aggregate number of people affected is Gamma distributed with shape and scale parameters values as 0.2031 and 3.25129E+08 (or 325,129,000). Future forecasts can be calculated using the Gamma distribution function. Figure 3.3 depicts the estimated aggregate economic damage/loss world-wide caused by natural disasters from year 1900 to 2011. As can be observed from the time series plot, in 1995, Kobe earthquake in Japan caused a major economic loss. Further, in 2004-2005, hurricane Katrina caused a major economic damage in southern United States and in 2008 Sichuan earthquake was the major cause of high economic loss. Again, in 2011 Japan suffered a major economic loss due to Honshu tsunami and earthquake. Furthermore, the trend indicates that the economic loss caused by natural disasters is exponentially increasing with time. This trend is similar to other trends for the number of disasters and the number of people affected. Identifying a best curve fit indicates that estimated damage is Weibull distributed with estimated shape and scale parameters as 0.3755 and 6019.37. Future economic loss forecasts can be calculated using a Weibull distribution function.

To consider the yearly inflation rate in calculating the estimated aggregate economic damage/loss world-wide caused by natural disasters. The time series equation has been modified by adding the yearly inflation rate as shows in equation (3.3) :

$$\text{The estimated aggregate economic damage} = (13.342 \times 1.09377^{t}) \times (1 + r)^{t} \qquad (3.3)$$

Where :

t: Time period.

r: Inflation rate.

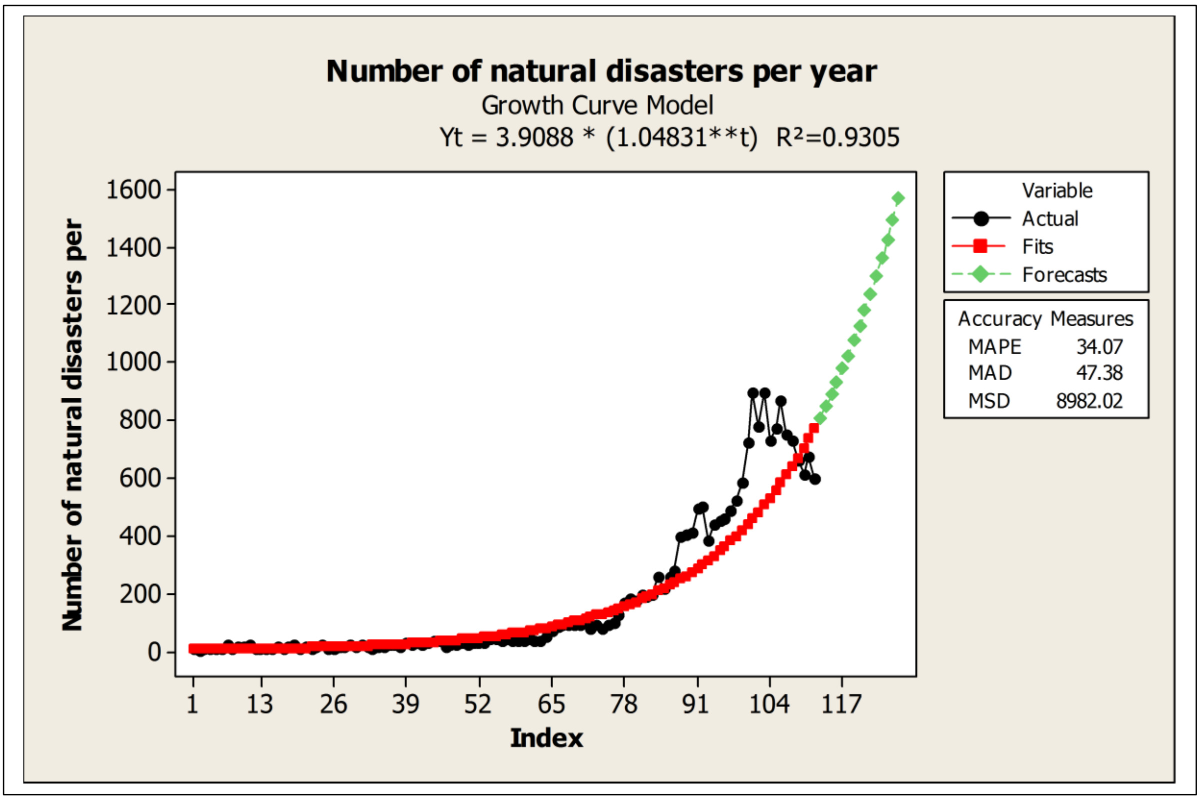


Figure 3.1: Number of disasters reported 1900 – 2011.

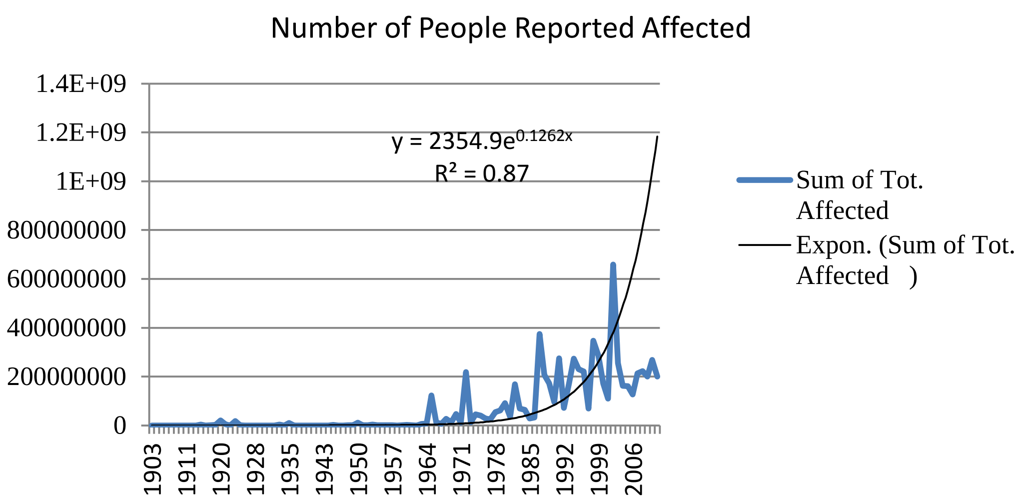


Figure 3.2: Number of people reported affected by natural disasters 1900-2011.

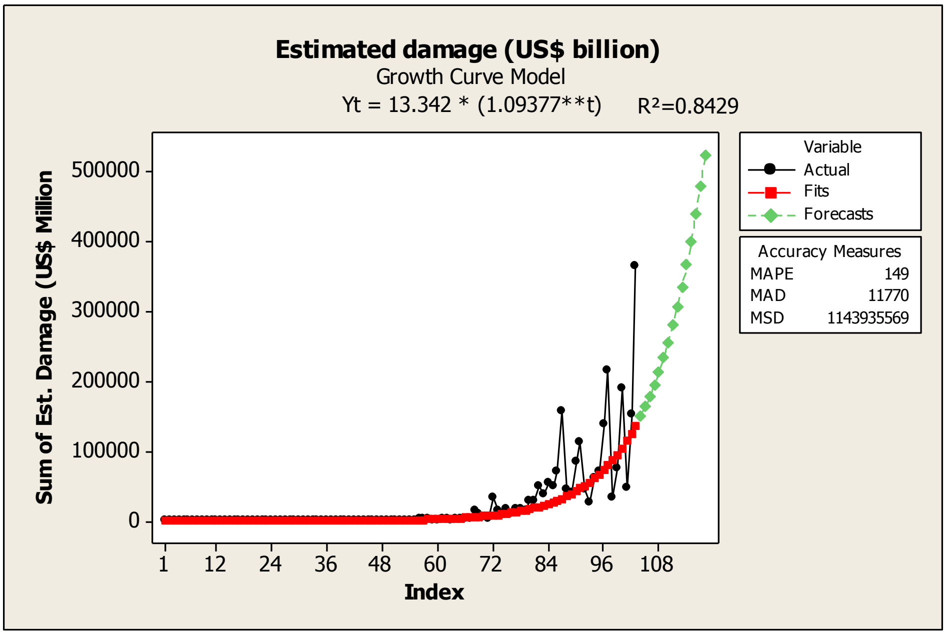


Figure 3.3: Estimated damage (US$ billion) caused by reported natural disasters 1900-2011.

Table 3.1 summarizes the results of goodness of fit test and the estimates of parameters of probability distribution. These findings are used in selecting the appropriate probability distribution functions to determine the future aggregate forecasts. The relief organizations can use the aggregate forecast values of number of disasters, number of affected people, economic loss and the number of people killed in the coming years to assess the future global demand of relief goods as part of the pre-disaster planning. It will assist in determining the logistical needs.

The relief organizations can consider and assess the total financial resources required and availability, staff availability, logistics capacity, transport information such as port operations, airport operations, road transport, water transport, fuel and so on, distribution plans, commodities and supplies required. Inability of the relief agencies to accurately forecast and assess the impact of natural disasters, the resulting needs and the response capacities, would result in inadequate help, poor utilization of resources, shortage of funds and a poorly planned response. Donor agencies and governments can also use the aggregate forecasts to determine the required amount of funds to be raised in advance, fuel purchased for air operations and cargo movement, number of helicopters rented, and other preparedness activities. Aircrafts are very expensive and should be considered when supplies are urgently needed in a location where no other mode of transport can be used in a short time frame.

Table 3.1: Results of Probability Distribution Identification.

Random Variable	**Best fit Distribution Identified**	**Estimates of Parameters**
Number of people affected by natural disasters	Gamma	Shape parameter = 0.2399 Scale parameter = 1.2447×10^9
Estimated damage caused by disasters	Weibull	Shape parameter = 0.3755 Scale parameter = 6019.3707
Number of people killed by disasters	Weibull	Shape parameter = 0.8711 Scale parameter = 1.54607×10^6
Number of disasters	Weibull	Shape parameter = 0.6548 Scale parameter = 126.6

3.2.2 linear regression modelling :

Different models for all the variables have been found but all are not acceptable because the R^2 value is less than 85% , so the models are rejected . The following MINITAB output shows that the R^2 value is 70.6% .

```
The regression equation is
ln Number of people affected by natural disasters = 198 - 0.0943 Year - 0.150
Continent - 0.0520 Disaster + 0.212 feq


Predictor       Coef   SE Coef       T      P    VIF
Constant      197.73     25.04    7.90  0.000
Year        -0.09429   0.01253   -7.53  0.000  1.012
Continent   -0.14955   0.05836   -2.56  0.011  1.027
Disaster    -0.05198   0.02391   -2.17  0.030  1.011
feq         0.211837  0.006374   33.23  0.000  1.028


S = 1.68944   R-Sq = 70.8%   R-Sq(adj) = 70.6%


Analysis of Variance

Source           DF       SS      MS       F      P
Regression        4  3457.91  864.48  302.88  0.000
Residual Error  499  1424.25    2.85
Total           503  4882.17


Source     DF   Seq SS
Year        1   105.34
Continent   1   182.13
Disaster    1    18.34
feq         1  3152.11
```

3.2.3 Neuro fuzzy network :

Neuro-fuzzy is an associative memory method that contains of fuzzy nodes instead of simple output and input nodes, and it uses neural network learning tasks to improve every part of the fuzzy knowledge individually. Learning in a disconnected network is earlier than learning in a complete network (Jang, 1993). An Adaptive Neuro-Fuzzy Inference System (ANFIS) is a fuzzy implication system applied in the framework of an adaptive neural system. By using a hybrid learning process, ANFIS can concept an input-output mapping established on both knowledge and human as fuzzy, If-Then rules and required input -output data couples for neural networks training. ANFIS construction is shown in Figure 3.4 , where x and y are the data, f is the result, A_i and B_i are the input relationship functions, w_i and w_n are the rules fire strengths. ANFIS is a construction which is functionally correspondent to a Sugeno-type fuzzy rule base. It is a technique for modifying a current rule base with a learning procedure based on a gathering of training data. This permits the rule base to adjust. Training data is used to learn the neuro fuzzy structure by adapting its factors (which in essence are fuzzy set participation function factors) and using a normal neural network procedure which operates a gradient search, for example the mean square output error is minimized. As of the ANFIS Architecture, it is experiential that for specified values of premise factors, the overall output can be stated as a linear grouping of the following parameters.

ANFIS modeling and prediction of disasters situations starts by finding a data set (input-output data points) and separating it into training and validating data groups. The training data group is used to find the first premise factors for the membership roles by equally spacing each of the participation roles. A threshold value for error between the real and expected output is determined. The resulting parameters are calculated using the least squares method. At that time, an error for each data couple is calculated. If this error is greater than the threshold value, the principle factors are updated using the back spread neural networks. This procedure is completed when the error becomes less than the threshold value. After that, the testing data are used to associate the model with real method for validating purposes.

Each data group is obtained by arbitrarily dividing the total data into two sets: training set which is used to construct the model and testing set which is used to confirm the model.

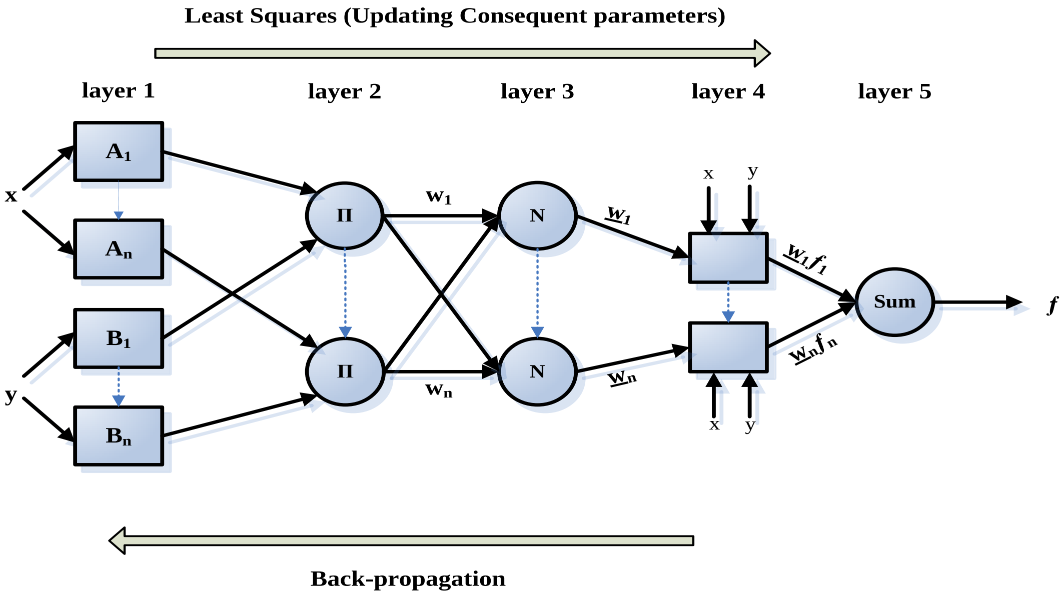


Figure 3.4: ANFIS architecture

Adaptive Neuro-Fuzzy Analysis

The fuzzy logic toolbox of Matlab 12 software was used to obtain the results.

ANFIS Prediction of the economic losses

The data set of the significant variables is now used to build another model that is based on neuro-fuzzy analysis. Following is the result of the model. The neural network training for building a fuzzy model for prediction of economic losses used 2000 training data points, MF has been found gauss2mf, and 800 learning epochs.

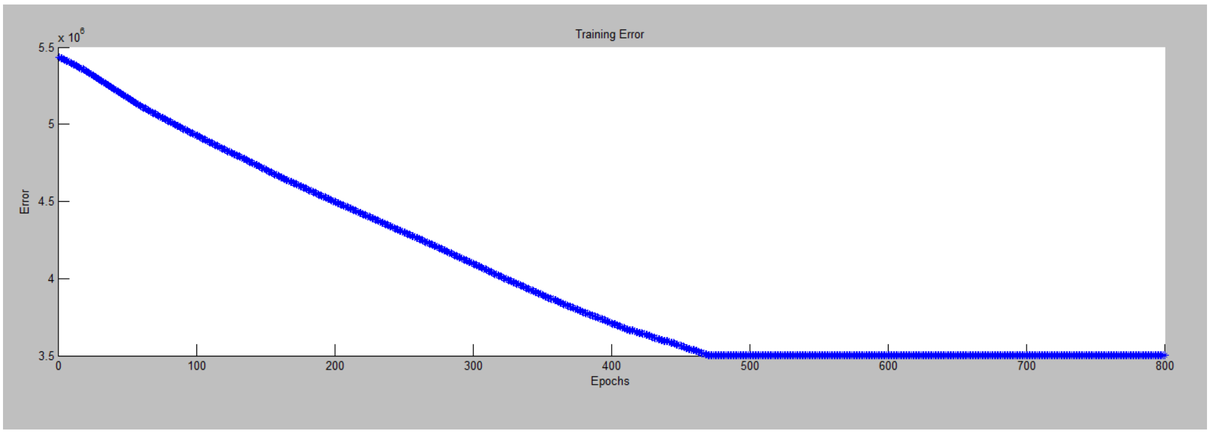


Figure 3.5: ANFIS training curve.

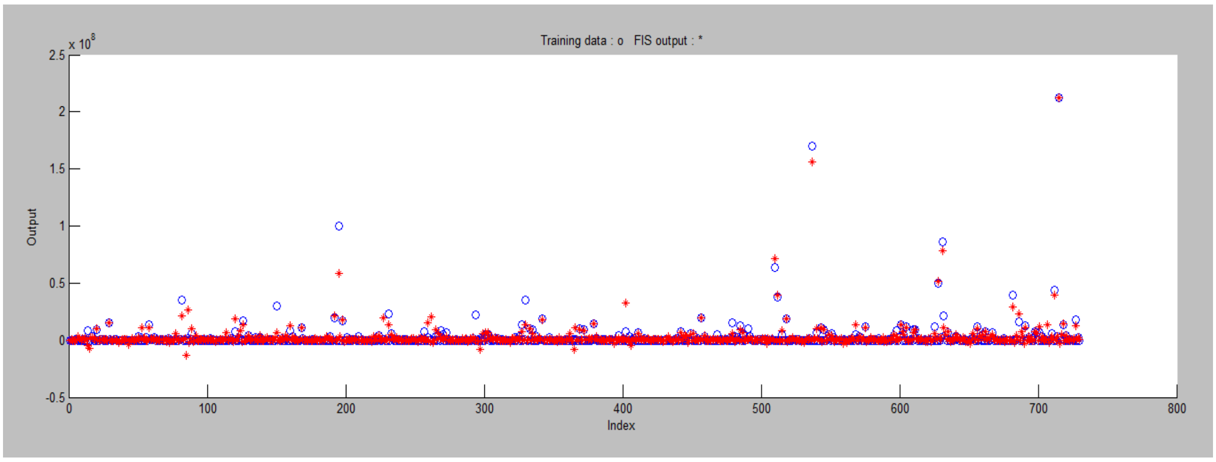


Figure 3.6 Actual and Predicted the economic losses.

Figure 3.5 shows the training curve of ANFIS. A comparison between the actual and ANFIS predicted economic losses after training is shown in Figure 3.6, which illustrates that the system is well-trained to model the actual economic losses. The ANFIS-predicted economic losses is depicted in Figure 3.7 in the form of surface plot of economic losses as a function of the disaster code and year. Figure 3.8 shows another surface plot of economic losses as a function of number of disaster and year. Different types of membership functions (MF) of the inputs and outputs were tested to train the ANFIS prediction system and the best one had the minimum error value of gauss2mf. The final (MF) were tuned and updated by the ANFIS model to achieve a good mapping of the input variables to the economic losses output. Figure 3.9 shows the final fuzzy inference system (FIS) used to predict the economic losses.

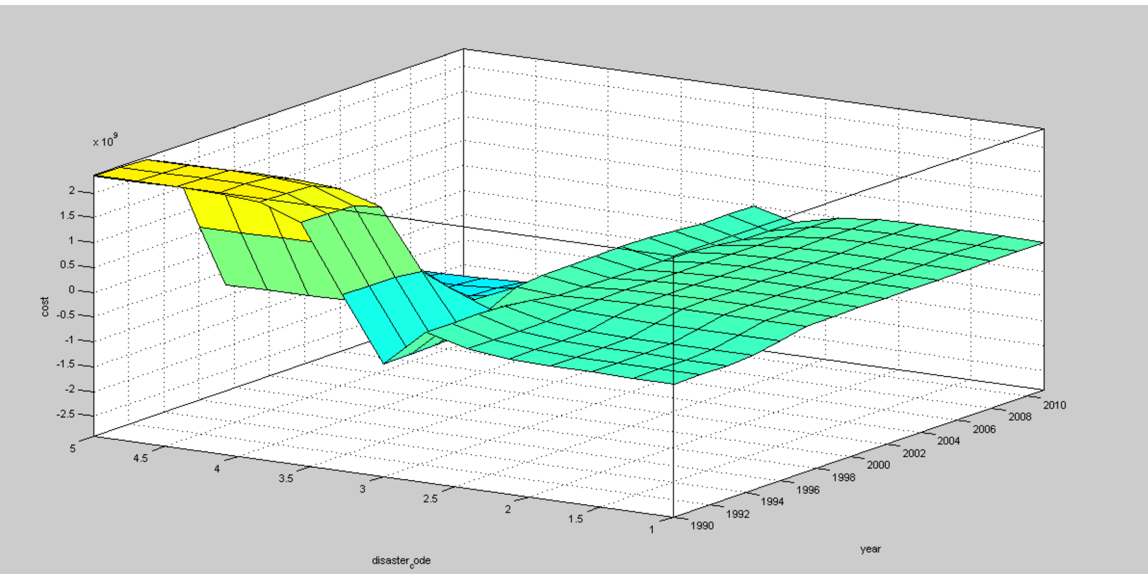


Figure 3.7. A model for predicting the economic losses.

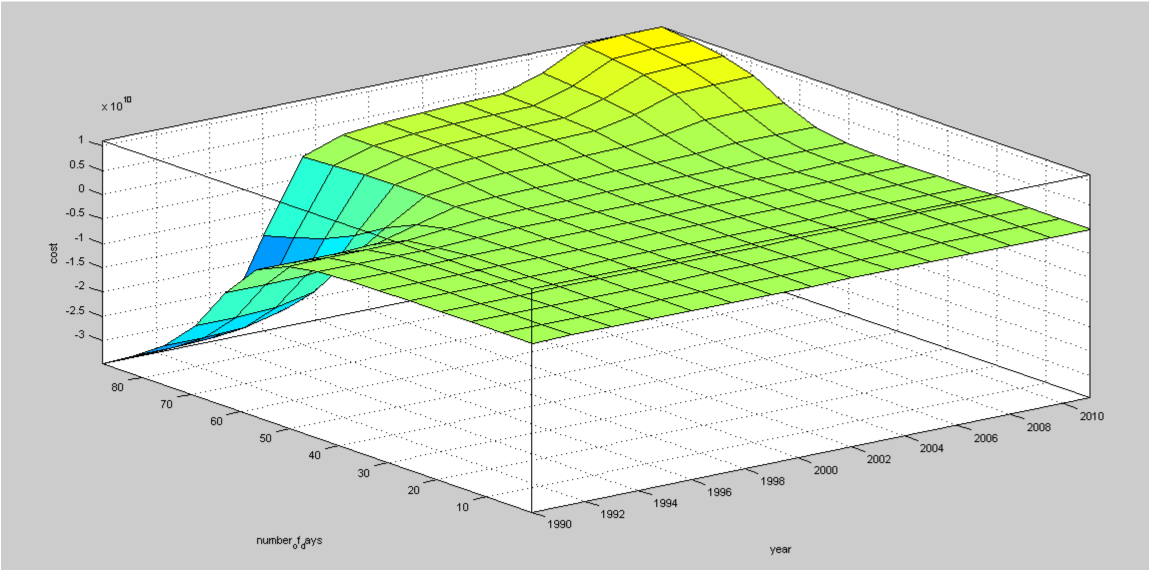


Figure 3.8. A model for predicting economic losses.

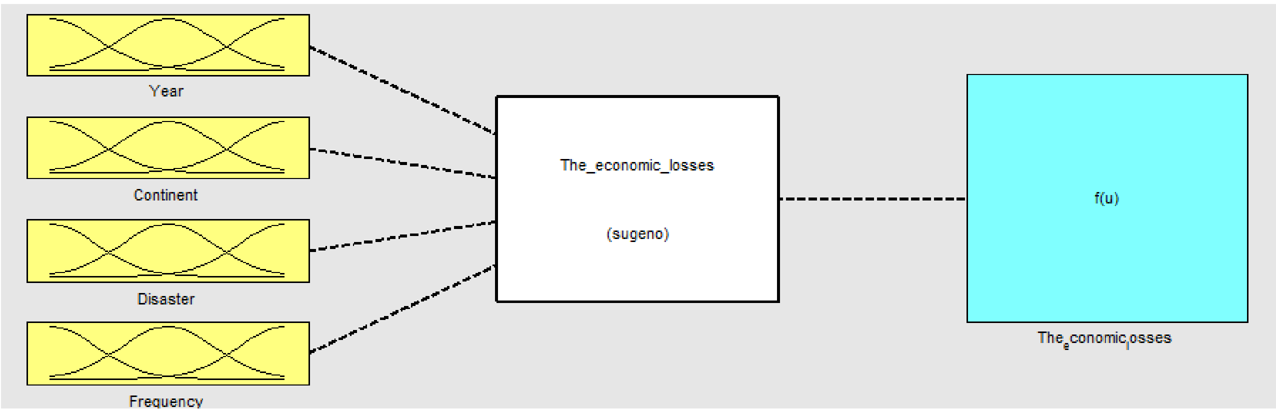


Figure 3.9. The final fuzzy inference system (FIS) for predicting economic losses.

3.3 Local predictions tools:

3.3.1 Logistic Regression Models:

Statistical modeling is generally an iterative process. A minimal/initial model is developed, and fitted to a data set and examined. Further models for the data may then be proposed and specified, with the form of the current model being based on the information provided by the previous models. Throughout the last thirty or so years, statistical modeling has been centered around the classical Linear Models (LMs) which have focused on the normal distribution properties and homogeneity (constant variance), for example, regression models, and ANOVA models (Aitkin, 1989;Knoop et al., 2007). Logistic regression, being one special case of regression models (Liang and Ziyou, 2008) is well suited for the study of categorical outcome variables (Jing and Mahmassani, 2011;Liang and Ziyou, 2008) , which is commonly dichotomous, such as disease being present versus absent, and a set of predictor variables. The models work by appropriating the probability of response to the proportions of responses observed (Bergerud, 1996).

Logistic regression models are developed often in wildlife management and management-related research. A common use of these models is to make informed decisions, where models produced by statistics collected in the past are used to make predictions about future observations from the same study area or study population, (Gude et al., 2009;Chen et al., 2008); these models have become the standard analysing tools for making predictions (Kuss, 2002).

According to the collected data, there are multi response categories, and multi variable Multi Ordinal Logistic Regression (MOLR) used in this research.

3.3.1.1 Methodology

Logistic Regression extends the techniques of Multiple Regression Analysis to study situations in which the result variable is groups. In the situation of assessing a learning program, for example, forecasts may be made for the dichotomous result of improved/not-improved or failure/success. Also, in a medical setting, an outcome might be presence/absence of a disease (Dayton, 1992). Furthermore, in a disaster situation, an output might be type of disaster or location of the disaster or something else.

The important model fundamental multiple regression analysis (MRA) conjectures that a continuous result variable is, in theory, a linear combination of a set of error and forecasts. Thus, for an output variable, Y, and a set of C forecast component, X1,...,Xp, the MRA model is of the form (Dayton, 1992):

$$Y = \alpha+\beta_1X_1+\beta_2X_2+....+\beta pXp+E = \alpha+\sum_{j=1}^{p} \beta jXj+E \tag{3.4}$$

Where,

α is the Y-intercept (i.e., the estimated rate of Y when all X's are equal to 0)

β_j is a multiple regression coefficient.

E is the forecast error. If error is present, the output model is the predicted value of Y:

$$E(Y|X1,.....,Xp) = Y' = \alpha+\sum_{j=1}^{p} \beta_j \times X_j \qquad (3.5)$$

Note that Y=$\widehat{Y}$ +ϵ. Therefore, we can understand the MRA model as follows:

Each observed score, Y, is made up of a predictable or expected, element, $\widehat{Y}$, that is a function of the forecast variables X1,...,Xp, and an error, or unpredictable element, ϵ, that characterizes error of measurement or unreliability and/or error in the choice of the model (i.e., mis-specification) (Dayton, 1992).

The MRA model plotted above is valid when the output variable, Y, is continuous, but is not correct for conditions in which Y is categorical. For instance, if Y takes on the value of 0 for "failure," and 1 for "success", the multiple regression model would not outcome in forecast values restricted to exactly 1 or 0. Actually, these forecast values would be wide over an interval that has uninterruptible values such as 0.4 or 0.31 and could even be values greater than 1 and/or contain negative values also.

The model for logistic regression analysis, defined below, is a more accurate representation of the situation when an output variable is a group or a set of numbers.

The model for logistic regression analysis assumes that the result variable, Y, is categorical (e.g., type of disaster). For simplicity, and because it is the case most usually encountered in repetition, it is assumed that Y is a type of disaster, taking on values between 1 and 11. In concept, the hypothetical populace proportion of cases for which Y = 1 is defined as:

$$\pi = P(Y=1) \qquad (3.6)$$

Then, the theoretic proportion of cases for which

$$Y=0 \text{ is } 1- \pi= P(Y = 0) \qquad (3.7)$$

In the lack of other information, the values are estimated by the example proportion of cases for which Y = 1. Though, in the regression situation, it is assumed that there is a set of forecast variables, X1, X2, X3..., Xp, that are connected to Y and, therefore, offer further information for expecting Y. For hypothetical, mathematical reasons, LRA is created on a linear model for the normal logarithm of the odds (i.e., the log-odds) in favor of Y = 1:

$$\text{Log}_e \left[\frac{P(Y=1|X1,.....Xp)}{1-P(Y=1|X1,.....Xp)} \right] = \text{Log}_e\, \pi/(1-\pi) \qquad (3.8)$$

$$= \alpha+\beta_1X_1+\beta_2X_2+....+\beta pXp = \alpha+\sum_{j=1}^{p} \beta jXj \quad (3.9)$$

It could be illustrated that in the LRA model, p is a restricted probability of the form P(Y=1| X1,...,Xp). That is, it is expected that "flood" is more or less possible dependent on mixtures of values of the forecast variables. The log-odds in equation (3.7), as definite above is also identified as the logit transformation of p and the logical method defined here is sometimes recognized as logit analysis (Dayton, 1992).

The LRA model above is matching with the MRA model but the log-odds in favor of Y = 1 changes the estimated value of Y. There are two basic explanations underlying the improvement of the model above.

First, odds obey multiplicative probabilities, rather than additive rules. Because logarithms exchange multiplication into addition, taking the logarithm of the odds permits for the simpler, additive model.

Second, there is a (relatively) simple exponential transformation for changing log-odds back to probability. In particular, the opposite transformation is the logistic role of the form:

$$P(Y=1 \mid X_1,....,X_P) = \frac{e^{\alpha+\sum_{j=1}^{p} X_j\beta_j}}{1+e^{\alpha+\sum_{j=1}^{p} X_j\beta_j}} = \frac{1}{1+e^{-[\alpha+\sum_{j=1}^{p} X_j\beta_{j]}}} \quad (3.10)$$

3.3.1.2 Results and discussion

The following is the Minitab output Table for Ordinal Logistic Regression

Results

Ordinal Logistic Regression: disaster code versus Continent code, Region code, ...

```
Link Function: Logit

Response Information

Variable        Value  Count

disaster code   1         17

                2        504

                3        388

                4        178
```

5	1540
6	14
7	23
8	322
9	1114
10	105
11	181
Total	4386

Logistic Regression Table

Predictor	Coef	SE Coef	Z	P	Odds Ratio	95% CI Lower	Upper
Const(1)	8.73363	9.06756	0.96	0.135			
Const(2)	12.2755	9.06460	1.35	0.136			
Const(3)	12.9411	9.06469	1.43	0.113			
Const(4)	13.1750	9.06474	1.45	0.146			
Const(5)	14.7008	9.06531	1.62	0.105			
Const(6)	14.7143	9.06532	1.62	0.105			
Const(7)	14.7365	9.06532	1.63	0.104			
Const(8)	15.0612	9.06544	1.66	0.097			
Const(9)	16.9773	9.06600	1.87	0.061			
Const(10)	17.4605	9.06615	1.93	0.054			
Continent code	-0.125693	0.0249788	-5.03	0.000	0.88	0.84	0.93
Region code	0.0171010	0.0041285	4.14	0.000	1.02	1.01	1.03
Month	-0.0119569	0.0079550	-1.50	0.133	0.99	0.97	1.00

```
Year         -0.0070485  0.0045300  -1.56  0.120   0.99   0.98
1.00

Log-Likelihood = -30.667

Test that all slopes are zero: G = 44.124, DF = 4, P-Value = 0.000

Goodness-of-Fit Tests

Method    Chi-Square     DF      P

Pearson      24620.1  28686  1.000

Deviance     10943.4  28686  1.000

Measures of Association:

(Between the Response Variable and Predicted Probabilities)

Pairs         Number  Percent  Summary Measures

Concordant  3995286     53.1  Somers' D              0.85

Discordant  3442189     45.8  Goodman-Kruskal Gamma  0.86

Ties          82361      1.1  Kendall's Tau-a        0.76

Total       7519836    100.0
```

Interpreting the outcomes:

The different parts of the result have been numbered for ease of description as follows:

Response Information: gives data about the response variable "Type of disaster".

- There were 17 subjects with Drought (Value = 1).
- 504 subjects with Earthquake (Value =2).
- 388 subjects with Epidemic (Value =3).
- 178 subjects with Extreme temperature (Value =4).
- 1540 subjects with Flood (value =5).
- 14 subjects with Biological (Value =6).
- 23 subjects with Mass movement dry (Value =7).
- 322 subjects with Mass movement wet (Value =8).
- 1114 subjects with Storm (Value =9).
- 105 subjects with Volcano (Value =10).
- 181 subjects with Wildfire (Value =11).

Logistic regression Table shows the approximations of the β coefficients, standard error of the β coefficients, z values (z = β coefficient ÷ standard deviation; also called Wald Statistic), and p values. The 95% confidence intervals and odds ratio for every coefficients are also shown. All variables with p value less than 0.15 are significant in the model.

Log Likelihood tells us about the possibility of the observed outputs given the β coefficients. Since the likelihood is at all times less than 1 it is normal to use the logarithm of the likelihood and multiply it by −2; hence the term −2LL. Its value offers a measure of how close the model fits the figures. The log likelihood statistic is similar to the error sum of squares in multiple linear regressions. As such it is a pointer of how much unexplained data remains after appropriating the model. A great value means an unwell fitting model. In this study the value of Log likelihood is -30.667, so the model is good fitting the data.

In this case the p value is 0.000, significant p value at the lowest of the result Table tells us that there is a significant connotation between at least one descriptive variable and the result by testing whether all slopes are equal to zero. If the p assessment were not significant there would be no requisite to go further. Next the p values for every term in the model are considered. These values express whether or not there is statistically momentous association between a particular explanatory variable and the result. Next, is the statistic G or the log-likelihood ratio check which is a Chi-square test. This statistic checks the null hypothesis that all the coefficients associated with forecasters equal zero as opposed to these coefficients not all being equal to zero. A G value of 44.24, with a p-value of 0.000, representative that there is an appropriate proof the coefficients for disaster type is different from zero.

Goodness-of-Fit: Goodness-of-fit tests are typically common tests that evaluate the fitted model's whole departure from the experiential data (Jing and Mahmassani, 2011). Two traditional international goodness of fit tests for the logistic regression models have been adapted; the Pearson test and the residual Deviance (Kuss, 2002) which match the fit of the model with the saturated model. These two are available for most of the ordinal regression models for categorical responses. However, below the null hypothesis of a well fitted model, the distribution of the Goodness of fit statistics are even approximately chi-square distributed only if most expected counts formed by the cross cataloguing of the response levels and all covariates are larger than 5% (Abeysekera and Sooriyarachchi, 2009).

The Goodness of fit Hypothesis is:-

H0: The model fits well to the data.

H1: The model does not fit well to the data.

In this study the p-values of the two tests are equal to 1.0, larger than the stated α - level of 0.05, representing that the model satisfies the Goodness of fit at 5% significance level; the null hypothesis will not be rejected.

Measures of Association. This portion provides measures of association to assess the quality of the model. The Table of concordant, discordant, and tied pairs are calculated by forming all possible pairs of observations with different response values. The Table shows the percent of concordant and numbers, tied pairs and discordant, as well as the common correlation checks. The numbers given are the percentages of sets in every of these classes, clearly, the greater the percentage of concordant sets the better is the fitting of the model. In the situations of this research there were 45.8% discordant and 53.1% pairs concordant giving 85% better chance for pairs to be concordant than discordant; so the model has a good predictive ability. A series of three different tests of rank correlation computed under Summary measures consider concordance discordance as follows:

Somer's D is found by the following (Preston, 2006):

$$\frac{\text{How many more concordant than discordant pairs exist}}{\text{Total number of pairs}} \tag{3.11}$$

Goodman-Kruskal-Gamma is found by the following (Preston, 2006):

$$\frac{\text{How many more concordant than discordant pairs}}{\text{Total number of pairs number of ties}} \tag{3.12}$$

Kendall's Tau is obtained as follows (Preston, 2006):

$$\frac{\text{How many more concordant than discordant pairs}}{\text{Total number of pairs including pairs with same response}} \tag{3.13}$$

These associations may vary from zero to one; therefore, a higher correlation implies a stronger connection. Greater values for Kendall's Tau, Goodman-Kruskal-Gamma and Somer's D– show that the model has a good predictive ability. In this case, the values vary between 0.76 and 0.85 which imply a realistic prediction capability.

3.3.2 Decision tree Modelling :

Decision trees are usually used to provide decision-making in an uncertain situation. For instance, in finding the probability of disaster happening for each country and the approximate number of victims before the disaster happens or when it happens, so the government and the relief organization can predict the number of victims. This information can be gathered to respond faster to the situation. Decision trees sort this type of analysis reasonably easy to apply.

A decision tree has three kinds of nodes: (a) decision (b) chance, and (c) leaf. The branches created from a decision node exemplify options existing; those originating from an unplanned node characterize uncontrollable occasions. At every chance node, every division is assigned a restricted probability like the probability of the occurrence represented by the branch, conditioned upon the information existing at the node. Leaf nodes exemplify the probable endpoints, i.e. the consequences of the decisions and chance results connected with the path from the start of the tree.

Decision Tree Analysis: If you could somehow define exactly what would occur as a result of selecting each choice in a decision, making decisions would be easy. In calculating the relief materials quantity decisions, where there are significant uncertain variables which make the approximate number of victims very hard to predict, the objective of choosing the optimal solution, the top set of selections at the decision nodes—can be reached by applying a “roll-up” method to the decision tree. Beginning with the leaf nodes and continuing recursively to the root, each node is tagged by the value of the condition it exemplifies. Every chance node is labeled with the probable value of its replacements, and every decision node is labeled with the value of the optimal that has the biggest rate. Consider the next instance to describe the “roll-up” idea.

Suppose a disaster happens in one country in the world, in this situation the lead time will be approximately zero. So the government and the relief organization should take the decision “What is the approximate number of victims?“ very fast. By using the proposed Decision tree Model, which is built on the disaster historical data, they can find an approximate number of people to start relief operation, after that they can modify it to the actual data according to the current situation. Table 3.2 shows a sample of the Decision tree Model with all the available data .

Table 3.2: The Decision tree Model.

P(Disaster)	Continent	P(Hit by natural disasters)	Region	P(Hit by natural disasters)	Country	P(Hit by natural disasters)	Type of disaster	Average of no_killed	Average of No. of Victims	Average of total- damages ('000 US$)	Average # natural disasters	P(Hit by natural disasters)
73.23%	Africa	15.58%	Eastern Africa	40.82%	Burundi	6.19%	Earthquake	3	120	0.0	1	**3.7%**
							Epidemic	82	104887	0.0	7	**25.9 %**
							Flood	2	5122	0.0	13	**48.1 %**
							Storm	4	8228	0.0	6	**22.2 %**
					Comoros	1.83%	Epidemic	7	749	0.0	2	**25.0 %**
							Flood	2	2500	0.0	1	**12.5 %**
							Storm	0	300	0.0	1	**12.5 %**
							Volcano	0	71050	0.0	4	**50.0 %**
					Djibouti	1.61%	Epidemic	19	886	0.0	3	**42.9 %**
							Flood	65	80000	706.3	3	**42.9 %**
							Storm	0	775	0.0	1	**14.3 %**
					Eritrea	0.92%	Flood	0	3507	0.0	2	**50.0 %**
							Insect infestation	0	0	0.0	1	**25.0 %**

							Storm	3	15675	5165.0	1	**25.0 %**
					Ethiopia	11.70%	Drought	0	12600000	0.0	1	**2.0%**
							Epidemic	90	2879	0.0	6	**11.8 %**
							Flood	48	40857	423.7	38	**74.5 %**
							Insect infestation	0	0	0.0	1	**2.0%**
							Mass movement dry	13	0	0.0	1	**2.0%**
							Mass movement wet	13	97	0.0	2	**3.9%**
							Volcano	5	2000	0.0	1	**2.0%**
							Wildfire	0	5	0.0	1	**2.0%**
					Kenya	12.61%	Drought	0	2700000	0.0	1	**1.8%**
							Earthquake	1	0	50000.0	2	**3.6%**
							Epidemic	117	401337	0.0	17	**30.9 %**
							Flood	20	48656	398.0	31	**56.4 %**
							Mass movement wet	14	7	0.0	4	**7.3%**
					Madagascar	8.72%	Epidemic	121	3055	0.0	1	**2.6%**
							Flood	10	27197	30000.0	5	**13.2 %**
							Insect infestation	0	0	3500.0	1	**2.6%**
							Storm	50	178318	20141.3	31	**81.6 %**
					Malawi	5.96%	Earthquake	2	10368	0.0	2	**7.7%**
							Epidemic	113	3257	0.0	7	**26.9 %**

							Flood	35	88918	1986.8	16	**61.5%**
							Storm	11	8	0.0	1	**3.8%**
					Mauritius	**1.38%**	Storm	2	1975	30900.0	6	**100.0%**
					Mozambique	**7.80%**	Drought	5	1709750	25000.0	2	**5.9%**
							Earthquake	4	1476	0.0	1	**2.9%**
							Epidemic	170	27950	0.0	9	**26.5%**
							Flood	6	93546	0.0	7	**20.6%**
							Mass movement wet	87	2500	0.0	1	**2.9%**
							Storm	25	240024	2965.4	13	**38.2%**
							Wildfire	49	3023	0.0	1	**2.9%**
					Reunion	**0.92%**	Storm	5	948	12500.0	4	**100.0%**
					Rwanda	**4.59%**	Earthquake	41	1143	0.0	2	**10.0%**
							Epidemic	25	614	0.0	7	**35.0%**
							Flood	16	6184	1.1	8	**40.0%**
							Mass movement wet	15	2646	0.0	3	**15.0%**
					Seychelles	**0.69%**	Earthquake	3	4830	30000.0	1	**33.3%**
							Flood	5	1237	1700.0	1	**33.3%**
							Storm	0	6800	0.0	1	**33.3%**
					Somalia	**8.72%**	Drought	0	200000	0.0	1	**2.6%**

							Earthquake	298	105083	100000.0	1	**2.6%**
							Epidemic	130	2397	0.0	11	**28.9 %**
							Flood	106	83694	0.0	24	**63.2 %**
							Storm	30	0	0.0	1	**2.6%**
					Tanzania Uni Rep	**10.55%**	Drought	0	1900000	0.0	2	**4.3%**
							Earthquake	3	1698	0.0	5	**10.9 %**
							Epidemic	282	3925	0.0	13	**28.3 %**
							Flood	24	23205	172.3	22	**47.8 %**
							Mass movement wet	13	150	0.0	1	**2.2%**
							Storm	2	1553	0.0	2	**4.3%**
							Wildfire	0	0	0.0	1	**2.2%**
					Uganda	**8.03%**	Earthquake	2	16667	23333.3	3	**8.6%**
							Epidemic	45	8026	0.0	13	**37.1 %**
							Flood	18	23238	83.3	12	**34.3 %**
							Mass movement wet	140	5387	0.0	3	**8.6%**
							Storm	6	2538	0.0	4	**11.4 %**
					Zambia	**3.67%**	Epidemic	40	3558	0.0	8	**50.0 %**
							Flood	6	365273	2957.1	7	**43.8 %**
							Mass movement wet	9	150	0.0	1	**6.3%**
					bab we	**4.13 %**	Epidemic	159	46322	0.0	11	**61.1**

												%
							Flood	10	9764	40720.0	5	**0.1%**
							Storm	4	0	600.0	2	**0.0%**

3.4 Summary:

Using the past time series data, a trend analysis of the data has been conducted and the best fit curve or probability distribution has been identified. The estimates of the parameters of probability distribution are used to calculate the forecasts. These forecasts are used by the various international and national humanitarian organizations in emergency logistics planning. This leads to better coordination of search and rescue activities and efficient evacuation of injured people. Furthermore, overall health conditions of everyone in the affected area depend on the timely availability of commodities such as food shelter and medicine.

The second type of prediction was used linear regression modelling but the model was rejected due to the R^2 value being less than 85% . Subsequently, Neuro fuzzy network models, which were acceptable, have been applied to the same variables. Ordinal Logistic Regression has been identified by using MINITAB. This model is used to calculate the forecasting for type of disaster.

There are a few limitations of Ordinal Logistic Regression method of forecasting. Larger samples are needed than for linear regression because maximum likelihood coefficients are large sample estimates. A minimum of 50 cases per predictor is recommended. Careful consideration is needed to interpretation when comparing multiple categories. Like any regression model, ordinal logistic regression has assumptions, which should be carefully scrutinized.

Finally, Decision tree Model helps to find an approximate number of people to start relief operation. This information can be gathered to respond faster to the situation; after that they can modify it to the actual data according to the current situation.

CHAPTER 4

Simulation Model

4.1 Introduction :

The difficulty of most of real-world systems is very much linked to their stochastic nature as well as to the relations among their key elements and variables. Although traditional methods such as models and methodical methodologies contribute confidence and knowledge about a real-world system they offer hypothetical answers whose validity is very much dependent on early assumptions.

Historically, the most appropriate method to come up with solutions to solve difficulties in real-world complex systems is a Modeling and Simulation (M&S) based approach. Suggestions of simulation in relations of imitation of reality can be found throughout our history (from the very early Egyptian culture to the Roman Empire with the simulated epic battles). The unstoppable development of digital computers has led to simulation converting a serious enabling tool for many scientific castigations and social sciences.

In Banks (1998), simulation is definite as the imitation of the processes of a real-world structure over the time that contains the design of an “artificial history” of the real-system. According to Longo and Oren (2008) simulation is used for two diverse but equally important groups of usage: (i) exercise and (ii) performance trials. When the “artificial history” of the scheme is used with the goal of improving the capability on the processes of the real-world system, then simulation is used for exercise purposes. To this end, teaching people for operations can be reached by using live simulation, constructive simulation and virtual simulation (Kelly and Phillips, 1998). When the “artificial history” of the real world system is used with the goal of performance trials then simulation is a great problem solving approach and judgment support tool for carrying out what-if examination, assessing different choices, designing and working complex systems.

In recent years, M&S has been widely used for assistance both training and experimental analysis in disaster situations. Areas of interest contain, among others, catastrophes management and evacuation problems both on small and large scale.

The aim of this model is different from commercial uses that rather than reducing fleet size and costs, it is wanted to transport relief materials to reach their destinations where they can be aided or provided in the minimum possible period and do not exceed the 72 golden hours. Both suffering people and commodities are considered into a priority order.

4.2 Model Building :

The simulation model building involves 8 different stages as shown in Figure 4.1.

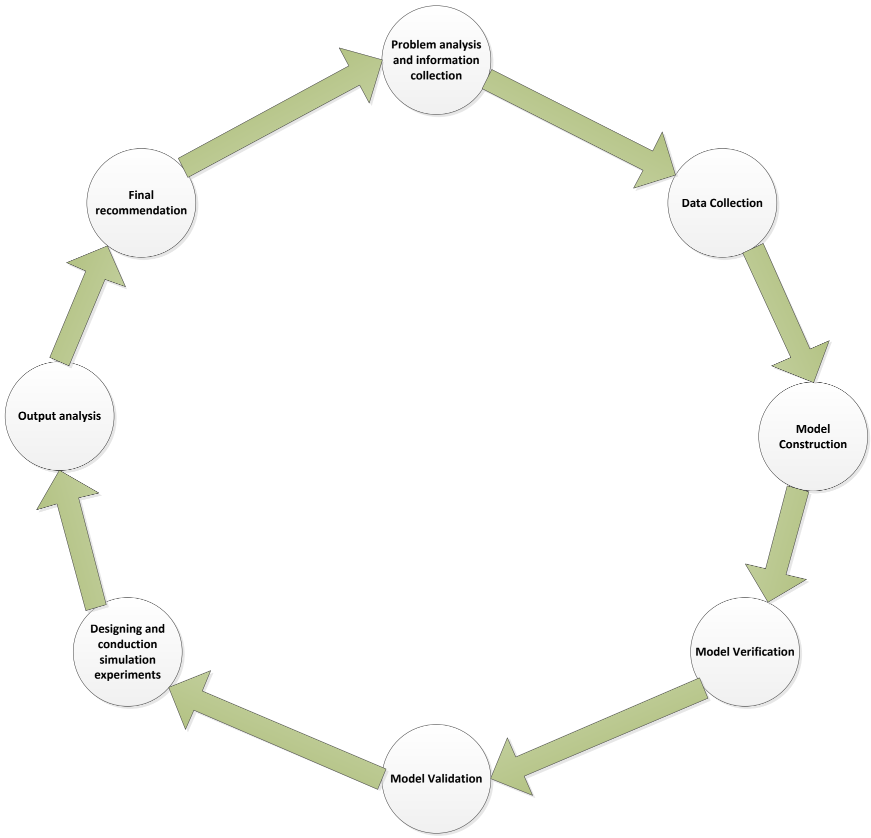


Figure 4.1: Simulation model building stages (Tayfur and Benjamin, 2007).

4.2.1 Problem analysis and information collection :

The problem has been defined in chapter one. The main target for this model is to predict demand for the disaster so that the government and non-government organizations can deal with this situation. For example , they will have a predicted value of the demand and the location of the disaster by using the historical data so that they can determine the inventory warehouse location and the inventory control.

4.2.2 Expected Output :

The expected output includes the following :

- The delivery time,
- Number of disasters in each country,
- Number of each type of disaster,
- Disaster demand, and
- Inventory level in each inventory warehouse .

4.2.3 Data Collection:

By using different sources of data, the following information has been collected to be used inside the ARENA logic, which will make the model deal with the actual situations.

- The probability of the disaster occurrence,
- The probability of each type of disaster,
- The probability of each type of disaster in each country in the world,
- The number of disasters happening each day,
- The average demand due to each type of disaster and for each country,
- Facility location and distance between each country and the facility, and
- What is the items need for victims.

4.2.4 Variable and parameters calculation to use in the model :

4.2.4.1 The Probability of disaster occurrence:

The probablity of disaster occurences has been calculated by counting the number of days the disaster happened in and the number of days disasters did not happen between 1985 and 2011. Table 4.1 summarizes the result which is used in the first stage of the model .

Table 4.1: – A summary the Probability of disaster occurrence

year	Total disaster happen	Total no disaster	P(happen)	P (not)
1985	139	226	38.08%	61.92%
1986	170	195	46.58%	53.42%
1987	211	154	57.81%	42.19%
1988	206	159	56.44%	43.56%
1989	220	145	60.27%	39.73%
1990	254	111	69.59%	30.41%
1991	251	114	68.77%	31.23%
1992	219	146	60.00%	40.00%
1993	244	121	66.85%	33.15%
1994	255	110	69.86%	30.14%
1995	232	133	63.56%	36.44%
1996	262	103	71.78%	28.22%
1997	272	93	74.52%	25.48%
1998	297	68	81.37%	18.63%
1999	286	79	78.36%	21.64%
2000	326	39	89.32%	10.68%
2001	312	53	85.48%	14.52%
2002	348	17	95.34%	4.66%
2003	303	62	83.01%	16.99%

2004	333	32	91.23%	8.77%
2005	320	45	87.67%	12.33%
2006	308	57	84.38%	15.62%
2007	301	64	82.47%	17.53%
2008	293	72	80.27%	19.73%
2009	286	79	78.36%	21.64%
2010	292	73	80.00%	20.00%
2011	277	88	75.89%	24.11%
AVERAGE			73.23%	26.77%

4.2.4.2 Probability of occurrence for each type of disaster

Table 4.2 shows the probability of each type of disaster. These probabilities are calculated by counting the number of each type of disaster divided by the total number of disasters for each year.

Table 4.2: – Probability of occurrence for each type of disaster

Type of disaster	Probability of occurrence	Cumulative Probability
Complex Disasters	0.12%	0.12%
Drought	3.99%	4.11%
Earthquake	14.84%	18.95%
Epidemic	4.71%	23.66%
Extreme temperature	1.14%	24.80%
Flood	14.04%	38.84%
Industrial Accident	5.78%	44.62%
Insect infestation	0.37%	44.99%
Mass movement	0.68%	45.67%
Mass movement wet	2.72%	48.39%
Miscellaneous accident	6.13%	54.52%
Storm	22.67%	77.19%
Transport Accident	18.58%	95.77%
Volcano	2.83%	98.60%
Wildfire	1.41%	100%

4.2.4.3 Probability of occurrence of each type of disaster in each country

The probability of occurrence for each type of disaster has been found for each country by using the historical data. The total number of each kind of disaster for each country divided by the total gives the probability of occurrence as shown in Table 4.3. The full result is shown in Appendix B.

Table 4.3: Probability of occurrence for each type of disaster in each country

Type of disaster	Country	Probability of occurrence	Cumulative Probability
Volcano	**Argentina**	1.33%	1.33%
	Cameroon	1.33%	2.67%
	Cape Verde Is	0.44%	3.11%
	Chile	3.11%	6.22%
	Colombia	4.89%	11.11%
	Comoros	2.67%	13.78%
	Costa Rica	2.67%	16.44%
	Ecuador	4.89%	21.33%
	El Salvador	0.44%	21.78%
	Ethiopia	1.33%	23.11%
	Greece	0.44%	23.56%
	Guadeloupe	0.44%	24.00%
	Guatemala	5.33%	29.33%
	Iceland	2.22%	31.56%
	Indonesia	23.11%	54.67%
	Italy	2.22%	56.89%
	Japan	6.67%	63.56%
	Martinique	0.44%	64.00%
	Mexico	4.44%	68.44%
	Montserrat	1.78%	70.22%
	New Zealand	0.89%	71.11%
	Nicaragua	2.22%	73.33%
	Papua New Guinea	6.22%	79.56%
	Peru	0.89%	80.44%
	Philippines	11.11%	91.56%
	Reunion	0.44%	92.00%

	Solomon Is	0.44%	92.44%
	Soviet Union	0.44%	92.89%
	St Vincent and The Grenadines	1.33%	94.22%
	Tonga	0.44%	94.67%
	Trinidad and Tobago	0.44%	95.11%
	United States	0.89%	96.00%
	Vanuatu	2.22%	98.22%
	Yemen	0.44%	98.67%
	Zaire/Congo Dem Rep	1.33%	100.00%

4.2.4.4 Number of victims (Demand)

The average number of people affected due to each kind of disaster has been found by using the historical data. Table 4.4 shows a sample of one type of disaster. The complete result is shown in Appendix C.

Table 4.4: Number of victims (Demand)

Country	Type of disaster	Number of victims (Demand)
Afghanistan	**Drought**	1311600
	Earthquake	29802
	Epidemic	16954
	Extreme temperature	92721
	Flood	23837
	Industrial Accident	130
	Insect infestation	0
	Mass movement dry	0
	Mass movement wet	50289
	Miscellaneous accident	165
	Storm	11331
	Transport Accident	31
	Wildfire	0

4.2.5 Model Construction :

The ARENA model has two stages. The first stage, which depends on the historical data, predicts if the disaster will happen or not, the type of disaster, the location of the disaster and the demand.

After that the second stage finds the lead time needed to deliver the relief material to disaster area, which includes the proposed method to improve the response for the disaster. Figure 4.2 shows the two stages of the model.

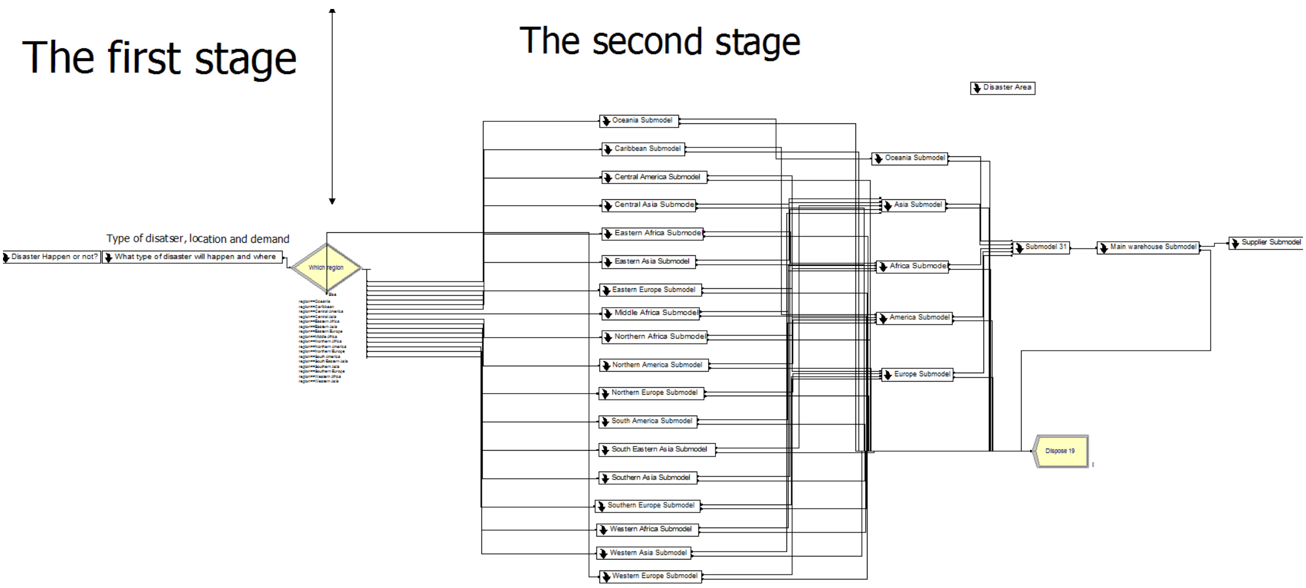


Figure 4.2: The ARENA model has two stages

4.2.5.1 First stage (Demand calculation)

The disaster situation has been modeled according to the historical data from the moment the disaster occurs till the delivery of the relief materials to disaster area. In the first stage, the probability of disaster occurrence has been determined as shown in Figure 4.3.

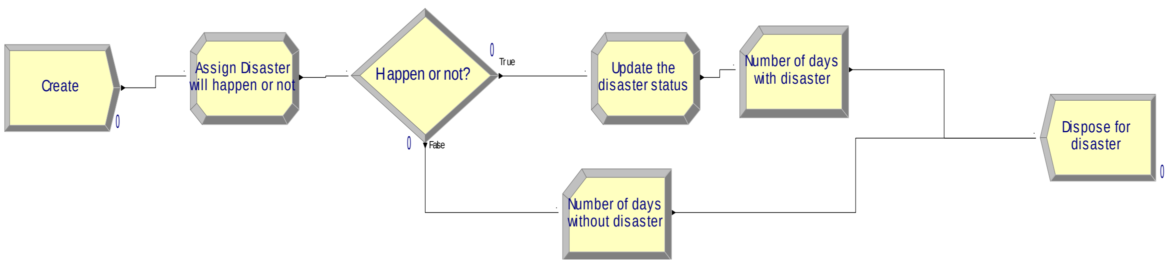


Figure 4.3: ARENA flow chart for the first stage

The create part in the figure starts the first run for the simulation, which gives one input for the model per day. After that a random number is generated from the program to decide whether the disaster happens or not. If the disaster does not happen the input goes to record to count the number of days then disposes to finish the simulation for this day. Otherwise, the disaster happens and then the next stage starts to determine what type of disaster will happen and where.

In the next stage the input information enters the model. Subsequently, a random number is generated inside ARENA to compare it with the cumulative probability of type of disaster as shown in Table 4.2 to choose the type of disaster. After that the model chooses the location of the disaster according to the probability of occurrence as shown in Table 4.7. Finally, the demand (number of victims) of each country is determined by using Table 4.8. Figure 4.4 shows part of choosing the type of disaster and location. From this stage the demand phase is found.

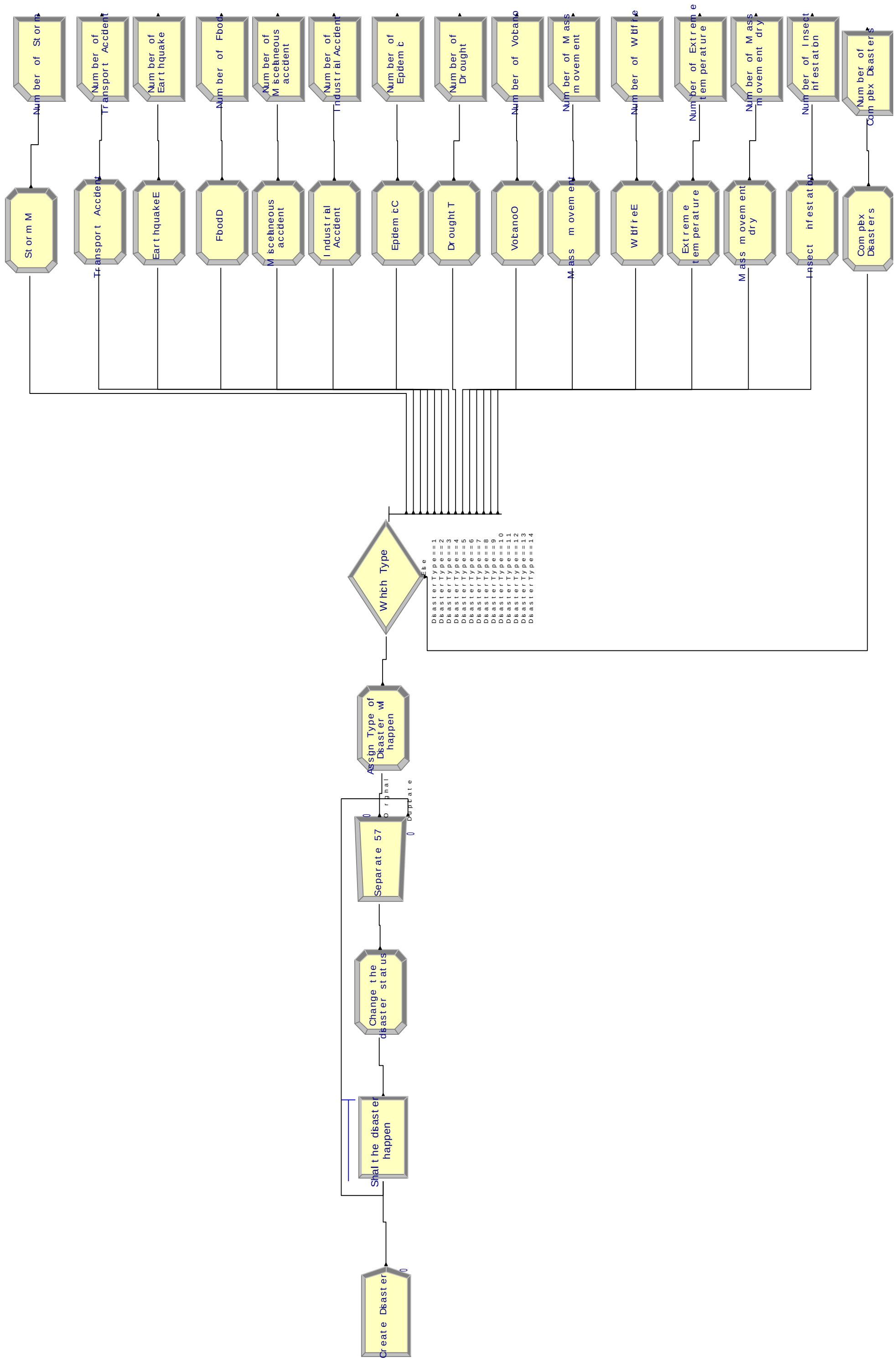


Figure 4.4: Choosing the type of disaster and location

This model can easily handle the time-varying demand if the data is available. This can be done by replacing the constant demand with the equation that represent the amount of demand change by time. For example, the model calculates the Japan demand by applying Eq.(4.1):

$$\text{Japan Demand} = \big((\text{Storm} * 138998) + (\text{Transportation} * 148) + (\text{Earthquake} * 34555) + (\text{Flood} * 326312) + (\text{Miscellaneous accident} * 705) + (\text{Industrial Accident} * 34033) + (\text{Epidemic} * 666845) + (\text{Drought} * 0) + (\text{Volcano} * 11472) + (\text{Mass movement} * 4279) + (\text{Wildfire} * 222) + (\text{Extreme temperature} * 10075) + (\text{Mass movement dry} * 0) + (\text{Insect infestation} * 0) + (\text{Complex Disasters} * 0)\,\big) \quad (4.1)$$

Where:
Storm, Transportation, Earthquake, Flood, Miscellaneous accident, Industrial Accident, Epidemic, Drought, Volcano, Mass movement, Wildfire, Extreme temperature, Mass movement dry, Insect infestation, Complex Disasters. Variables are equal to 0 or 1, depending on what type of disaster happened.
The constant number is the average number of victims for each disaster happening in Japan.

By replacing the constant number with the best expressions for time varying demands during the disaster as shown in the modified Equation (4.2).

$$\textbf{Japan Demand} = \big((\textbf{Storm} * \text{Exp.}_{Storm}) + \big(\textbf{Transportation} * \text{Exp.}_{\text{Transportation}}\big) + \big(\textbf{Earthquake} * \text{Exp.}_{\text{Earthquake}}\big) + (\textbf{Flood} * \text{Exp.}_{\text{Flood}}) + (\textbf{Miscellaneous accident} * \text{Exp.}_{\text{Miscellaneous accident}}) + (\textbf{Industrial Accident} * \text{Exp.}_{\text{Industrial Accident}}) + \big(\textbf{Epidemic} * \text{Exp.}_{\text{Epidemic}}\big) + \big(\textbf{Drought} * \text{Exp.}_{\text{Drought}}\big) + (\textbf{Volcano} * \text{Exp.}_{\text{Volcano}}) + (\textbf{Mass movement} * \text{Exp.}_{\text{Mass movement}}) + (\textbf{Wildfire} * \text{Exp.}_{\text{Wildfire}}) + \big(\textbf{Extreme temperature} * \text{Exp.}_{\text{Extreme temperature}}\big) + \big(\textbf{Mass movement dry} * \text{Exp.}_{\text{Mass movement dry}}\big) + (\textbf{Insect infestation} * \text{Exp.}_{\text{Insect infestation}}) + \big(\textbf{Complex Disasters} * \text{Exp.}_{\text{Complex Disasters}}\big)\big) \quad (4.2)$$

The problem modeled above is a multi-period planning problem where demands in the future time periods are indicated. In emergency situations knowledge of future demand is scarce except for some commodities, but the disaster coordination center frequently acknowledges supply that will be available in future time periods. So, it is possible to plan ahead and take future supply into account while preparing the plans (Yi, 2007). Note that in this multi-period planning problem, knowledge of future demand can be predicted based on current demand. Additionally, confirmed arrivals represent next period's supplies, thereby enabling continuity of routing plans over short periods of time.

Another variable that can be considered easily is the knowledge of the severity of the disaster. This can be done by calculating the probability of each severity level. For example, if the severity level is divided into high, medium and low, and the probability for each level is also shown in Table 4.5. Then a new assign needs to be added after choosing the type of disaster to define a new variable called disaster severity level. Eq. 4.3 needs to be added inside the assign to let ARENA choose the severity level according to past data.

Table 4.5: The probability of each severity level

Severity level	The probability	Cumulative Probability
High (1)	P	P
Medium (2)	n	P+n
Low (3)	(1-(P+n))	1

$$\text{Disaster severity level} = \text{DISC}(P, 1, (P+n), 2,1,3) \quad (4.3)$$

Where:
DISC: Discrete Probability Distribution.
1,2,3: The severity level code.
P: The probability of high disaster level occurring.
n: The probability of high disaster level occurring.

Then the best expressions for time varying demands during the disaster for each severity level need to be found. Table 4.6 shows time-varying demands expression for each level.

Table 4.6: The time varying demands expression for each severity level

Disaster type	High	Medium	Low
Storm	$\text{Exp}._{H.Storm}$	$\text{Exp}._{M.Storm}$	$\text{Exp}._{L.Storm}$
Transportation	$\text{Exp}._{\text{H.Transportation}}$	$\text{Exp}._{\text{M.Transportation}}$	$\text{Exp}._{\text{L.Transportation}}$
Earthquake	$\text{Exp}._{\text{H.Earthquake}}$	$\text{Exp}._{\text{M.Earthquake}}$	$\text{Exp}._{\text{H.Earthquake}}$
Flood	$\text{Exp}._{\text{H.Flood}}$	$\text{Exp}._{\text{H.Flood}}$	$\text{Exp}._{\text{H.Flood}}$
Miscellaneous accident	$\text{Exp}._{\text{H.Miscellaneous accident}}$	$\text{Exp}._{\text{H.Miscellaneous accident}}$	$\text{Exp}._{\text{H.Miscellaneous accident}}$
Industrial Accident	$\text{Exp}._{\text{H.Industrial Accident}}$	$\text{Exp}._{\text{H.Industrial Accident}}$	$\text{Exp}._{\text{H.Industrial Accident}}$
Epidemic	$\text{Exp}._{\text{H.Epidemic}}$	$\text{Exp}._{\text{H.Epidemic}}$	$\text{Exp}._{\text{H.Epidemic}}$
Drought	$\text{Exp}._{\text{H.Drought}}$	$\text{Exp}._{\text{H.Drought}}$	$\text{Exp}._{\text{H.Drought}}$
Volcano	$\text{Exp}._{\text{H.Volcano}}$	$\text{Exp}._{\text{H.Volcano}}$	$\text{Exp}._{\text{H.Volcano}}$
Mass movement	$\text{Exp}._{\text{H.Mass movement}}$	$\text{Exp}._{\text{H.Mass movement}}$	$\text{Exp}._{\text{H.Mass movement}}$
Wildfire	$\text{Exp}._{\text{H.Wildfire}}$	$\text{Exp}._{\text{H.Wildfire}}$	$\text{Exp}._{\text{H.Wildfire}}$
Extreme temperature	$\text{Exp}._{\text{H.Extreme temperature}}$	$\text{Exp}._{\text{H.Extreme temperature}}$	$\text{Exp}._{\text{H.Extreme temperature}}$
Mass movement dry	$\text{Exp}._{\text{H.Mass movement dry}}$	$\text{Exp}._{\text{H.Mass movement dry}}$	$\text{Exp}._{\text{H.Mass movement dry}}$
Insect infestation	$\text{Exp}._{\text{H.Insect infestation}}$	$\text{Exp}._{\text{H.Insect infestation}}$	$\text{Exp}._{\text{H.Insect infestation}}$
Complex Disasters	$\text{Exp}._{\text{H.Complex Disasters}}$	$\text{Exp}._{\text{H.Complex Disasters}}$	$\text{Exp}._{\text{H.Complex Disasters}}$

After that Eqn.(4.2) needs to be modified as shown in Eqn.(4.4).

$$\text{Japan Demand} = \textbf{High} * \big((\text{Storm} * \text{Exp.}_{H.Storm}) + (\text{Transportation} * \text{Exp.}_{\text{H.Transportation}}) + (\text{Earthquake} * \text{Exp.}_{\text{H.Earthquake}}) + (\text{Flood} * \text{Exp.}_{\text{H.Flood}}) + (\text{Miscellaneous accident} * \text{Exp.}_{\text{H.Miscellaneous accident}}) + (\text{Industrial Accident} * \text{Exp.}_{\text{H.Industrial Accident}}) + (\text{Epidemic} * \text{Exp.}_{\text{H.Epidemic}}) + (\text{Drought} * \text{Exp.}_{\text{H.Drought}}) + (\text{Volcano} * \text{Exp.}_{\text{H.Volcano}}) + (\text{Mass movement} * \text{Exp.}_{\text{H.Mass movement}}) + (\text{Wildfire} * \text{Exp.}_{\text{H.Wildfire}}) + (\text{Extreme temperature} * \text{Exp.}_{\text{H.Extreme temperature}}) + (\text{Mass movement dry} * \text{Exp.}_{\text{H.Mass movement dry}}) + (\text{Insect infestation} * \text{Exp.}_{\text{H.Insect infestation}}) + (\text{Complex Disasters} * \text{Exp.}_{\text{H.Complex Disasters}})\big) + \textbf{Medium} * \big((\text{Storm} * \text{Exp.}_{M.Storm}) + (\text{Transportation} * \text{Exp.}_{\text{M.Transportation}}) + (\text{Earthquake} * \text{Exp.}_{\text{M.Earthquake}}) + (\text{Flood} * \text{Exp.}_{\text{M.Flood}}) + (\text{Miscellaneous accident} * \text{Exp.}_{\text{M.Miscellaneous accident}}) + (\text{Industrial Accident} * \text{Exp.}_{\text{M.Industrial Accident}}) + (\text{Epidemic} * \text{Exp.}_{\text{M.Epidemic}}) + (\text{Drought} * \text{Exp.}_{\text{M.Drought}}) + (\text{Volcano} * \text{Exp.}_{\text{M.Volcano}}) + (\text{Mass movement} * \text{Exp.}_{\text{M.Mass movement}}) + (\text{Wildfire} * \text{Exp.}_{\text{M.Wildfire}}) + (\text{Extreme temperature} * \text{Exp.}_{\text{M.Extreme temperature}}) + (\text{Mass movement dry} * \text{Exp.}_{\text{M.Mass movement dry}}) + (\text{Insect infestation} * \text{Exp.}_{\text{M.Insect infestation}}) + (\text{Complex Disasters} * \text{Exp.}_{\text{M.Complex Disasters}})\big) + \textbf{Low} * \big((\text{Storm} * \text{Exp.}_{L.Storm}) + (\text{Transportation} * \text{Exp.}_{\text{L.Transportation}}) + (\text{Earthquake} * \text{Exp.}_{\text{L.Earthquake}}) + (\text{Flood} * \text{Exp.}_{\text{L.Flood}}) + (\text{Miscellaneous accident} * \text{Exp.}_{\text{L.Miscellaneous accident}}) + (\text{Industrial Accident} * \text{Exp.}_{\text{L.Industrial Accident}}) + (\text{Epidemic} * \text{Exp.}_{\text{L.Epidemic}}) + (\text{Drought} * \text{Exp.}_{\text{L.Drought}}) + (\text{Volcano} * \text{Exp.}_{\text{L.Volcano}}) + (\text{Mass movement} * \text{Exp.}_{\text{L.Mass movement}}) + (\text{Wildfire} * \text{Exp.}_{\text{L.Wildfire}}) + (\text{Extreme temperature} * \text{Exp.}_{\text{L.Extreme temperature}}) + (\text{Mass movement dry} * \text{Exp.}_{\text{L.Mass movement dry}}) + (\text{Insect infestation} * \text{Exp.}_{\text{L.Insect infestation}}) + (\text{Complex Disasters} * \text{Exp.}_{\text{L.Complex Disasters}})\big) \qquad (4.4)$$

Where :
High, Medium and Low Variables are binary, equal to 0 or 1. It depends on the severity level of disaster happening.

After the severity level of disaster is known. The model can easily give priority to high severity level disaster than others. This can be done by defining known attribute called priority. If high severity level disaster happens the priority becomes high and so on for the other levels. Then priorities type are changed from FIF to attribute called priority (high, medium, low).

Demand and supply quantities are adjusted as follows. Unsatisfied demand left over from the previous period is equal to the optimal quantity of unsatisfied demand. This quantity is added to amount of demanded commodity as well as additional quantities that came to be known during the current and previous re-planning times. Demand predictions for the next re-planning period are updated according to observations made during recent periods. Similarly, supplies left over from the previous plan take on the optimal values of the slack variables in the previous period. Additional past and future quantities are also added to the supply parameters.

4.2.5.1.1 First stage validation :

The model validation is a very important stage, which helps to see that the model represents the actual situation or not. In this stage the result of ARENA run is collected for the disaster happening, number of victims, and the number of disasters. Subsequently, the result is compared with the historical data.

- The disaster happening :

The number of days the disaster happens is found from ARENA output as shown in Table 4.6. The number of days was divided by 365 to see the probability of disaster from the model. With reference to the probability of disaster occurrence, as mentioned above in Table 4.2, the model is valid. Because the probability of disaster occurrence from ARENA model is 79 per cent while from the historical data is 74 per cent, the percentage deviation is 9 per cent which is acceptable (Crowther, 1985; Gentry, 1979). Also, with reference to Table 4.7 the probability of disaster occurrence, and the 95% confidence intervals of the simulated estimates against the actual values, all the probability values of disaster occurrence are within the confidence intervals. There is no big difference between the simulation estimates and the results from the probability of disaster occurrence, which help to reconfirm the validity of the simulation model with respect of disaster occurrence.

Table 4.7: ARENA model result for probability of disaster

	Number of days	**Simulation Probability of disaster[(a)]**	**Confidence interval $\alpha = 0.05$ (95%) Mean±tn-1,α/2Sx/√n**	**Actual mean[(b)]**	**(b-a)**
Disaster happens	291	0.79726	(0.6777, 0.7869)	0.7323	0.06496
Not	74	0.20274	(0.2131, 0.3223)	0.2677	0.06496

- Number of victims :

The UN has published the economic and Human impact of the disaster data for the last 12 years, which was our reference to validate the model. As Figure 4.5 shows that the total number of people affected in last 12 years is 2.7 billion, so the average number of victims is 225 million. The result from the ARENA model shown in Table 4.8 for total number of victims for one year is around 198 million. The percentage deviation from the average is 12% which is acceptable (Crowther, 1985; Gentry, 1979). Also, All the regional number of victims is within the 95% confidence intervals. There is no big difference between the simulated estimates and the results from the probability of disaster occurrence, which help in reconfirming the validity of the simulation model with respect to number of victims.

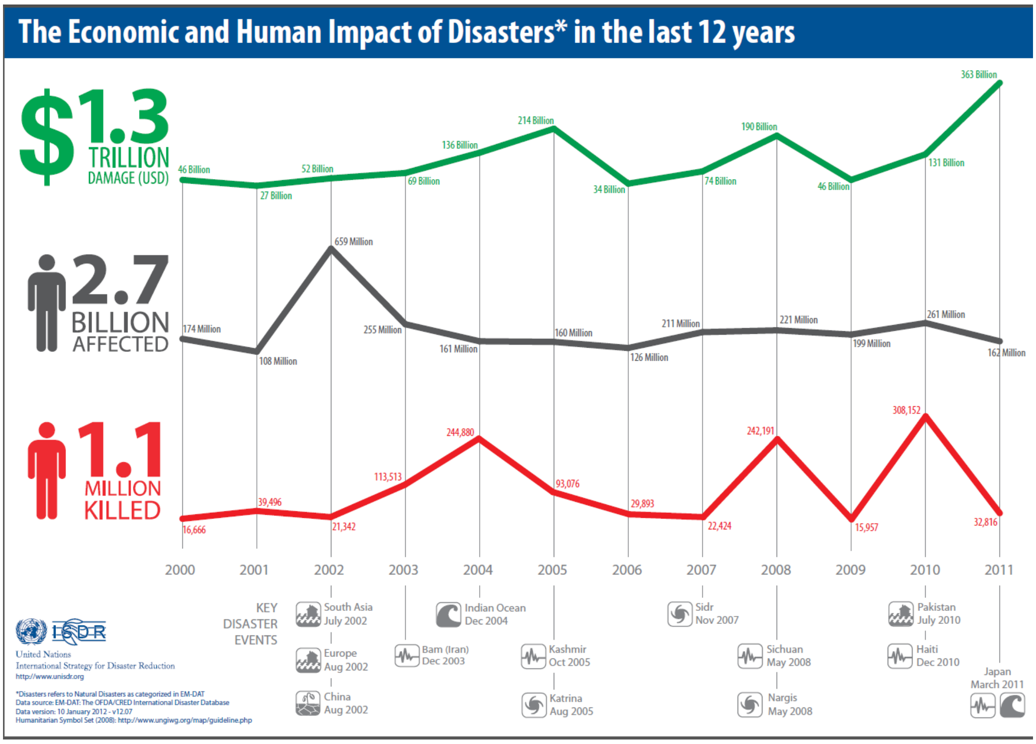


Figure 4.5: The economic and Human impact of the disaster in the last 12 years (UNISDR, 2012)

Table 4.8: ARENA model result for total number of victims for one year

Region	Simulation demand[a]	Confidence interval α = 0.05 (95%) Mean±tn-1,α/2Sx/√n	Actual mean [b]	Error%
Central Asia	3,984,481	(2858983, 3782153)	3320568	-19.99%
Eastern Asia	94,104,565	(67221062, 142296992)	104759027	10.17%
South-Eastern Asia	15,283,672	(8899949, 15475676)	12187813	-25.40%
Southern Asia	43,291,144	(23300236, 88496037)	55898137	22.55%
Western Asia	1,226,743	(727269, 1578105)	1152687	-6.42%
Western Africa	11,281,706	(10830602, 13621234)	12225918	7.72%
Eastern Africa	8,128,794	(5687799, 12772547)	9230173	11.93%
Middle Africa	1,294,983	(1091063, 1624549)	1357806	4.63%
Northern Africa	580,258	(38734, 1611984)	725359	20.00%
Eastern Europe	1,875,731	(1404205, 2027121)	1715663	-9.33%
Northern Europe	19,142	(0, 111207)	26807	28.59%

Southern Europe	444,814	(0, 971316)	407952	-9.04%
Western Europe	712,406	(302492, 1003064)	652778	-9.13%
Caribbean	1,598,976	(672851, 2057855)	1365353	-17.11%
Central America	1,616,972	(775900, 1987986)	1381943	-17.01%
Northern America	1,485,325	(0, 2508024)	1189363	-24.88%
South America	10,155,404	(7508077, 9934317)	8721197	-16.45%
Oceania	408,136	(0, 1523084)	552375	26.11%
Total	197,493,252	(162478181, 271263656)	216870919	**8.94%**

- Number of each type of disaster :

The total number of each type of disaster has been found from ARENA output. After that percentage of each type of disaster has been found. Subsequently, a comparison between these percentages and probability of occurrence of each one from the historical data has been done as shown in Table 4.9. According to this comparison, the model is valid (Crowther, 1985; Gentry, 1979). Also, all the probability values of occurrence of each type of disaster are within the 95% confidence intervals. There is no big difference between the simulation estimates and the results from the probability of each type of disaster, which help in reconfirming the validity of the simulation model with respect to the probability of each type of disaster.

Table4.9: Comparison between ARENA result and historical data for total number of each disaster

Type of disaster	Number of each disaster from ARENA	Simulation Probability[(a)]	Confidence interval $\alpha = 0.05$ (95%) $Mean \pm t_{n-1,\alpha/2} S_x/\sqrt{n}$	Actual mean[(b)]	(b-a)
Complex Disasters	1	0.16%	(-0.0716, 0.3196)	0.12%	0.000
Drought	30	4.82%	(2.728, 5.244)	3.99%	-0.008
Earthquake	82	13.18%	(12.51, 17.16)	14.84%	0.017
Epidemic	37	5.95%	(3.656, 5.764)	4.71%	-0.012
Extreme temperature	4	0.64%	(0.826, 1.459)	1.14%	0.005
Flood	90	14.47%	(12.186, 15.893)	14.04%	-0.004
Industrial Accident	35	5.63%	(4.750, 6.801)	5.78%	0.001
Insect infestation	4	0.64%	(0.118, 0.623)	0.37%	-0.003
Mass movement	21	3.38%	(0.264, 1.105)	0.69%	-0.027

Mass movement wet	7	1.13%	(2.160, 3.278)	2.72%	0.016
Miscellaneous accident	39	6.27%	(5.030, 7.226)	6.13%	-0.001
Storm	131	21.06%	(20.49, 24.84)	22.67%	0.016
Transport Accident	119	19.13%	(15.58, 21.58)	18.58%	-0.006
Volcano	12	1.93%	(1.763, 3.898)	2.83%	0.009
Wildfire	10	1.61%	(0.993, 1.818)	1.41%	-0.002

After the model validation for the first stage, the second phase of ARENA starts.

4.2.5.2 Second stage (Warehouse control and logistic) :

This stage is one of the most important processes in the relief operations. The input for this stage is the output from the first stage, which is the demand. Before the inventory control and logistic model, the location of the warehouse has been determined along with the distance between the warehouses and countries. Moreover, inventory levels for each warehouse has been calculated. Subsequently, these variables help to build the model.

4.2.5.2.1 Facility Location Problem in Emergency Logistic

For years, Operations Research methods have been used to a huge variety of problems to define the best geographical locations for facilities (Hale and Moberg, 2003; Klose and Drexl, 2005; Owen and Daskin, 1998; ReVelle and Eiselt, 2005). Facility location problems develop their importance due to two reasons: their direct effect on the system's timeliness of response to the demand and functional cost (Haghani, 1996). While the objective of facility location models addressing commercial sector problems is commonly to maximize profit or reduce cost, the models addressing community and emergency services instead focus on response time and user accessibility (Marianov et al., 1995; ReVelle et al., 1977).

Models with coverage-type objectives are generally used in facility location study and applications, mainly when response time is the main act principle (Daskin, 1995; Schilling et al., 1993). In covering-type facility location models, a source of demand is defined as covered if it is located inside a definite response distance or response time from a facility. The regular covering models look to select facilities between a finite set of candidate places such that all demand are covered with a least number of facilities. In disaster relief operation, this would mean that each possible demand point necessity be within a definite target response time of a facility in the relief organization.

- Center-of-Gravity Technique

In general, transportation costs are a function of time, distance, and weight. Also, the relief operation is a function of time, distance and availability of rescue materials. The center-of-gravity method is a numerical technique for a facility location such as a warehouse at the middle of movement in a geographic area based on distance and weight. This method identifies a set of coordinates designating a central location on a map relative to all other locations (Russell and Taylor, 2010).

The coordinates for the location of the new facility are calculated using the following formula:

$$x = \frac{\sum_{i=1}^{n} x_i * W_i}{\sum_{i=1}^{n} W_i}, \; y = \frac{\sum_{i=1}^{n} y_i * W_i}{\sum_{i=1}^{n} W_i} \qquad (4.5)$$

where

x, y= Coordinates of the new facility at center of gravity,

x_i, y_i= Coordinates of existing facility i , and

W_i= Annual weight shipped from facility i .

The coordinates for each country have been found from the nationmaster website Factbooks (2013). Also, the disaster data for each country has been collected from CRED. It is assumed that the number of disasters affecting the country is Wi., so this number has been calculated by using the data available from the CRED.

- <u>The regional warehouse:</u>

An assumption has been made that there are 18 regions in the world. For example, Central Asia, Eastern Asia, South-Eastern Asia, Western Africa and so on.

Equation (4.5) has been applied to each region to find the coordinates for each regional warehouse. For example, considering Eastern Asia, the following Table 4.10 shows the coordinates and the number of disasters for each country in the Eastern Asia region.

Table 4.10 Countries in the Eastern Asia region data

Country	Capital	Latitude	Longitude	Number of disasters
China	**Beijing**	39.91	116.4	57
Hong Kong	**Hong Kong**	22.28	114.15	6
Japan	**Tokyo**	35.67	139.78	16
Macao	**Macao**	22.2	113.55	0
Mongolia	**Ulan Bator**	47.92	106.92	1
North Korea	**Pyongyang**	39.02	125.75	1
South Korea	**Seoul**	37.57	127	7
Taiwan	**Taipei**	25.04	121.53	6

After applying Equation (4.5) the coordinates for the regional warehouse as shown in the Table 4.11, the same process is applied to all the regional warehouses; Table 4.12 shows the coordinates for all the warehouses.

Table 4.11 Countries in the Eastern Asia region results

Country	Capital	Latitude	Longitude
China	**Beijing**	2274.87	6634.80
Hong Kong	**Hong Kong**	133.68	684.90
Japan	**Tokyo**	570.72	2236.48
Macao	**Macao**	0.00	0.00
Mongolia	**Ulan Bator**	47.92	106.92
North Korea	**Pyongyang**	39.02	125.75
South Korea	**Seoul**	262.99	889.00
Taiwan	**Taipei**	150.24	729.18
Total		3479.44	11407.03
The warehouse coordinate		37.02	121.35

Table 4.12 The regional warehouse location

Continent	Region	Country	Latitude	Longitude
Asia	**Central Asia**	**Kazakhstan**	42.41	69.56
Asia	**Eastern Asia**	**China**	37.02	121.35
Asia	**South-Eastern Asia**	**Philippines**	7.46	110.01
Asia	**Southern Asia**	**Pakistan**	25.14	67.93
Asia	**Western Asia**	**Iraq**	33.56	40.45
Africa	**Western Africa**	**Burkina Faso**	11.61	-4.01

Africa	**Eastern Africa**	**Tanzania**	-8.77	37.96
Africa	**Middle Africa**	**Cameroon**	4.69	13.76
Africa	**Northern Africa**	**Libya**	30.67	16.65
Europe	**Eastern Europe**	**Ukraine**	50.16	28.79
Europe	**Northern Europe**	**Denmark**	55.48	4.80
Europe	**Southern Europe**	**Spain**	39.89	3.94
Europe	**Western Europe**	**France**	49.39	6.46
Americas	**Caribbean**	**Dominican Republic**	18.30	-71.09
Americas	**Central America**	**Mexico**	15.95	-92.32
Americas	**Northern America**	**United States(Maryland)**	39.48	-76.92
Americas	**South America**	**Bolivia**	-11.36	-68.89
Oceania	**Oceania**	**Australia**	-22.36	124.75

- The continent warehouses :

By applying the same equation for each continent, Table 4.13 shows the coordinates for each continent warehouse.

Table 4.13 The continent warehouse location

Continent	Country Name	Latitude	Longitude
Africa	**Sudan**	20.26	32.31
Asia	**Burma**	25.83	95.93
Europe	**Austria**	47.98	13.08
Americas	**Jamaica**	18.25	-77.50
Oceania	**Australia**	-22.36	124.75

- Main warehouse calculation :

By applying Equation 4.5 , the coordinates for the main warehouse have been found (20.7,-10.7) and these coordinates correspond to Sudan.

Facility location is one of the most important problems that can affect the relief operations. By considering three levels of warehouses and merging the concept of Just-In-Time and the campaign system in emergency supply chain, the approach leads to better coordination of search and rescue activities and efficient evacuation of injured people. Moreover, it decreases the number of people suffering from the disaster and improves the response time. Figure 4.6 summarizes all the facility locations in the world.

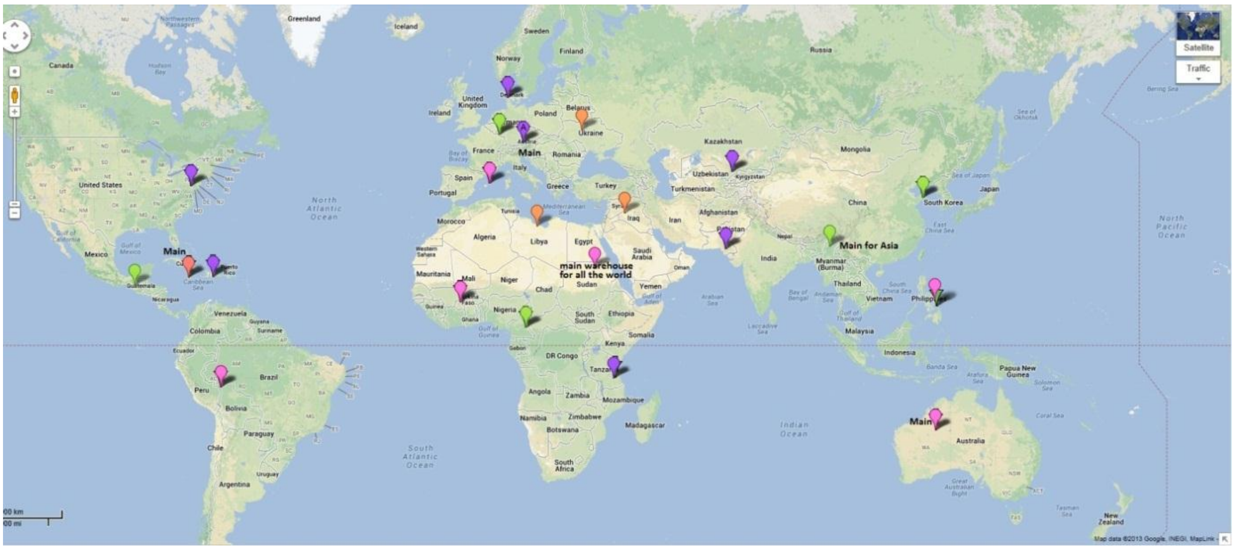


Figure 4.6: All the warehouses in the world map.

4.2.5.2.2 Distance between warehouses and countries :

The Latitude and Longitude coordinates for each country in the world are used to calculate the distance between two points. Table 4.14 shows the distance between warehouses and countries. Appendix D displays all the distances.

Table 4.14 The distance between warehouses and countries

Station 1	Station2	Distance KM
Western Europe	**South America**	9679
Western Europe	**Oceania**	13835
Caribbean	**Central America**	2137
Caribbean	**Northern America**	2197
Caribbean	**South America**	2973
Caribbean	**Oceania**	20001
Central America	**Northern America**	2812
Central America	**South America**	3598
Central America	**Oceania**	22043
Northern America	**South America**	5146
Northern America	**Oceania**	21094
South America	**Oceania**	19395
Central Asia	**Afghanistan**	789
Central Asia	**Albania**	4975
Central Asia	**Algeria**	6674
Central Asia	**American Samoa**	24685

Central Asia	**Andorra**	6804
Central Asia	**Angola**	7615
Central Asia	**Anguilla**	13479
Central Asia	**Antigua and Barbuda**	13382
Central Asia	**Argentina**	14934
Central Asia	**Armenia**	2514
Central Asia	**Aruba**	14275
Central Asia	**Australia**	11121
Central Asia	**Austria**	5350
Central Asia	**Azerbaijan**	1978

4.2.5.2.3 Inventory control:

Inventory control is very important in supply chain, but in emergency supply chain it is even more important due to time being the key point in it. In this situation the inventory level will stay at the maximum point. Whenever any order comes the warehouse delivers this order and replaces this quantity by placing an order to other warehouses. The historical data are used to calculate the average demand and the standard deviation (STD) for each regional warehouse. The inventory stock has been calculated by adding double amount of STD to the average demand. Table 4.15 shows the average demand, STD and the maximum demand for each regional warehouse.

Table 4.15 The average demand ,STD and the maximum demand for each regional warehouse

Region	Continent	Average Demand	STD	max	stock
Caribbean	**Americas**	98883	444965	5900012	988813
Central America	**Americas**	80124	345236	4993000	770595
Central Asia	**Asia**	108158	431073	3000000	970305
Eastern Africa	**Africa**	350239	1375115	23000000	3100469
Eastern Asia	**Asia**	1843138	8937449	105117864	19718036
Eastern Europe	**Europe**	111086	1056174	18000000	2223434
Oceania	**Oceania**	56051	442344	7000000	884688
Middle Africa	**Africa**	43275	210813	2400000	464901
Northern Africa	**Africa**	151903	856476	8600000	1864855
Northern America	**Americas**	31056	214541	2758162	460137
Northern Europe	**Europe**	10638	77722	780000	166081
South America	**Americas**	164047	987771	20000000	2139589
South-Eastern Asia	**Asia**	259680	875636	10000000	2010952

Southern Africa	**Africa**	179166	1227456	15000000	2634077
Southern Asia	**Asia**	2227101	17289063	300000000	36805226
Southern Europe	**Europe**	53005	389607	6000000	832219
Western Africa	**Africa**	164803	783882	12500000	1732566
Western Asia	**Asia**	53123	250199	3500000	553521
Western Europe	**Europe**	15544	123338	1750016	262220

On the other hand the same method has been used to find the inventory stock for the continent warehouse. Table 4.16 shows the required inventory stock in the warehouse to be ready to any sudden disaster.

Table 4.16 The inventory stock should be in the warehouse

Continent	Average Demand	STD	Max	Stock
Africa	217600	1055228	23000000	2328056
Americas	111413	696498	20000000	1504409
Asia	1212568	10664318	300000000	22541203
Europe	58614	646332	18000000	1351278
Oceania	56051	442344	7000000	940738

Finally, for the third level of inventory, which is the main warehouse, the level of inventory at the warehouse has been calculated as 13,249,774.

Second stage model construction:

After the demand, warehouse location and the distance have been found, the data need to build the next stage leading to decision making process. In the last step of the first stage, the model output are the type of disaster, location and the demand according to the historical data, which are the input for the next stage. This last phase starts with decision making process "Which regional warehouse this demand belongs to"; Figure 4.7 shows the decision making process.

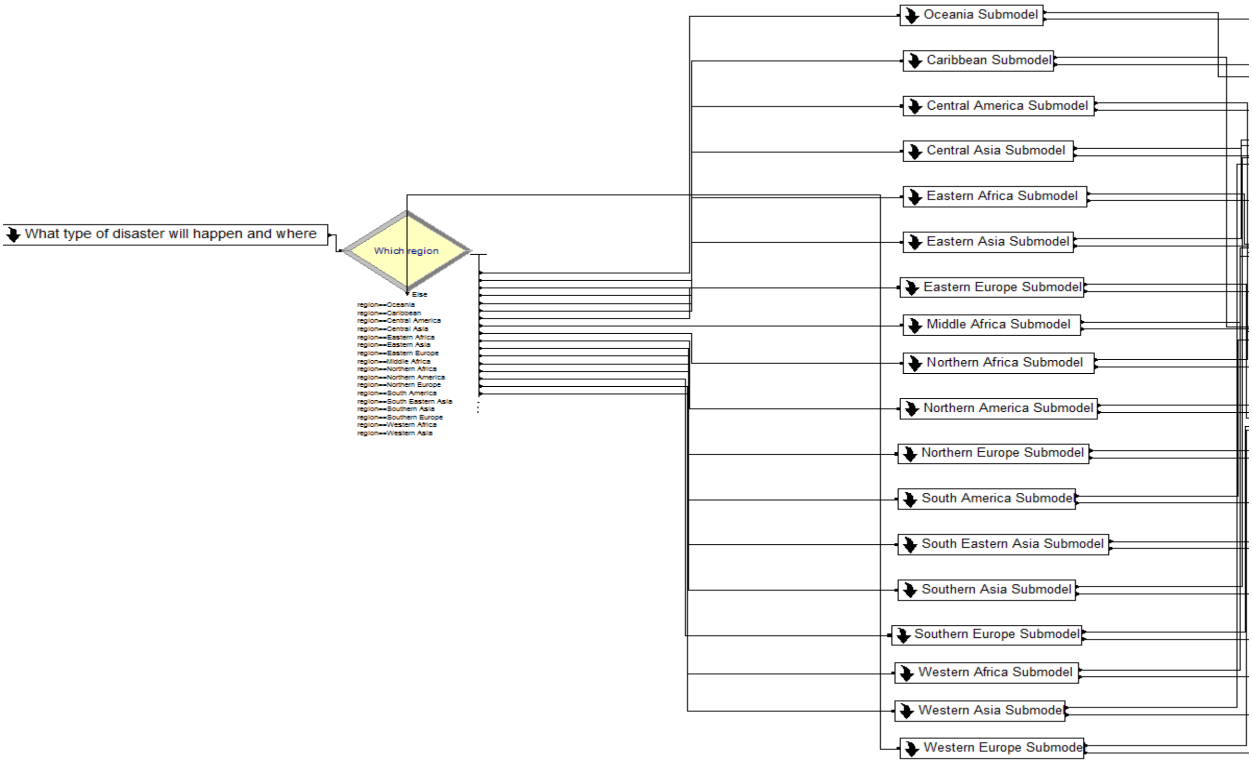


Figure 4.7: Which regional warehouse this demand belongs to

After the regional warehouse is chosen, the regional submodel starts work as follows. When the input enters the submodel it assigns the warehouse location Oceania as an example. After that a decide process checks the demand quantity equals zero or not. If the quantity equals zero, the model stops because there is no demand; else the model goes to the next decision making process to check if there is enough stock at the warehouse or not. In this situation, there are three options. The first one is that there is enough stock so these will be fast delivery from the stock. The second option is that there is small part from the demand in the stock. The last option is that there is zero inventory stock. Assumptions have been made for the second and the last options that the demand should be delivered in one shot. In these situations, an order to the other warehouses is made to send the required quantity to meet this demand. Holding time in this phase will be till the inventory stock equals demand. This holding time should be less than three days. Finally, checking process will see if the warehouse inventory is less than the level of inventory that was mentioned earlier in Tables 4.14 and 4.15. Figure 4.8 shows the logic that the submodel used to check the inventory and place an order to the other warehouse.

The delivery process has been taken to in consideration in this model. In the last stage of the model after checking the inventory, the model requests a transport to be used. Then it enters a pickup station. Inside this station, it checks the destination of the order as shown in Figure 4.9. Then it takes the distance, which is mentioned in Table 4.13, into consideration to calculate the time to deliver the order. When the order is received at the disaster, the demand quantity will be reduced by the amount received .

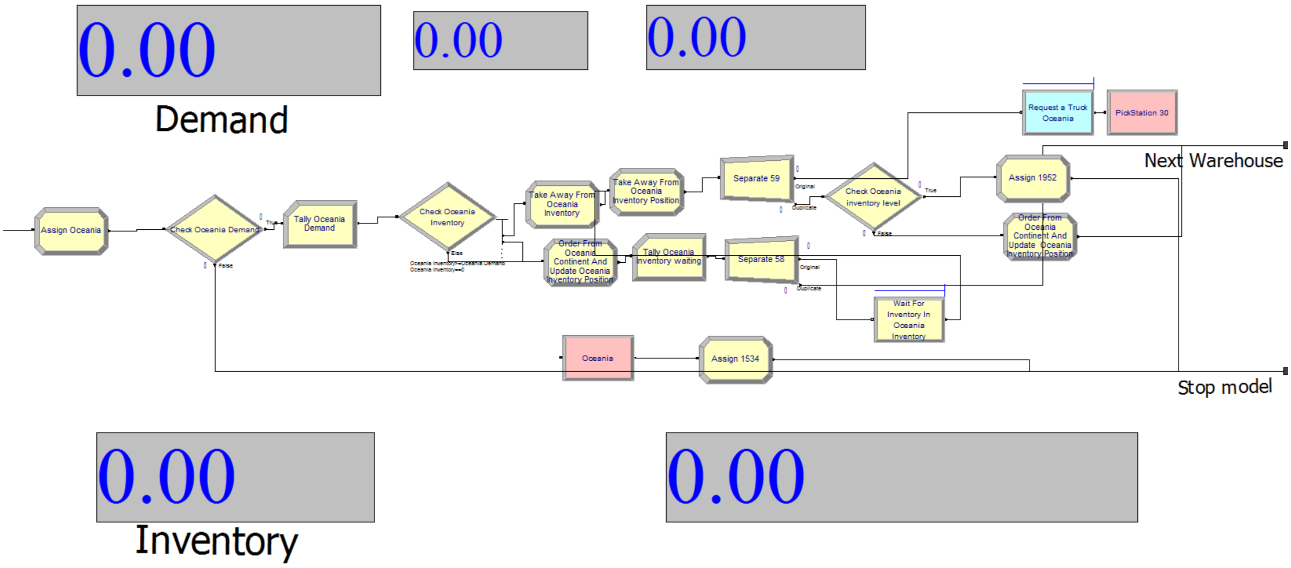


Figure 4.8: The submodel used to check the inventory

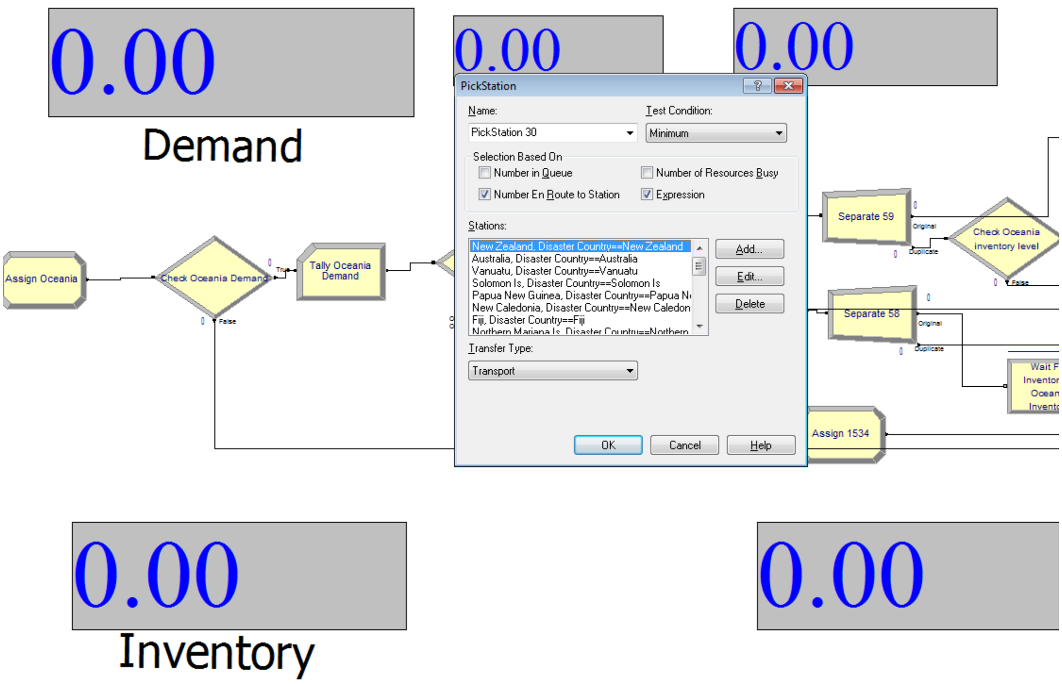


Figure 4.9: Check the destination of the order

After the regional warehouse checks the inventory, usually an order is placed to the Continent warehouse. The logical steps inside the continent warehouse are smaller compared to regional one. But there are two differences: the customer in this situation will be the regional warehouse rather than the victims, and the supplier will be the main warehouse rather than continent warehouse in the previous situations. Next the continent warehouse orders from the main warehouse. Before the order enters the main warehouse logic, it queues in different locations depending on the distribution of the demand. Figure 4.10 shows the queue and the release process for the order just to make sure that no conflict happens between any demand and the different locations.

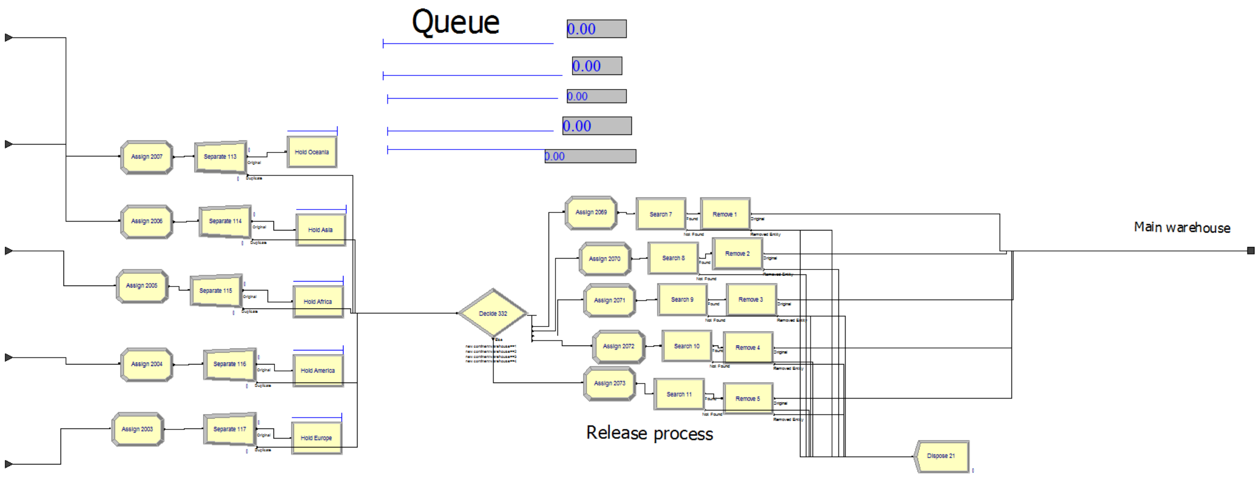


Figure 4.10: The queue and the release process for the order

After the order is released from the queue, the input for the main warehouse is entered. So the first step is to check if there is any available stock to cover the demand. If not an order is placed to the suppliers, which checks if they have the required quantity in their stock or not. If not then they check if there is any raw material to produce the items or not. If there is shortage of raw material, they order from their suppliers. After that they produce the demand and deliver it to the main warehouse, which distributes to the continent warehouse then to regional, finally to disaster area. Figure 4.11 shows the logic for the production process.

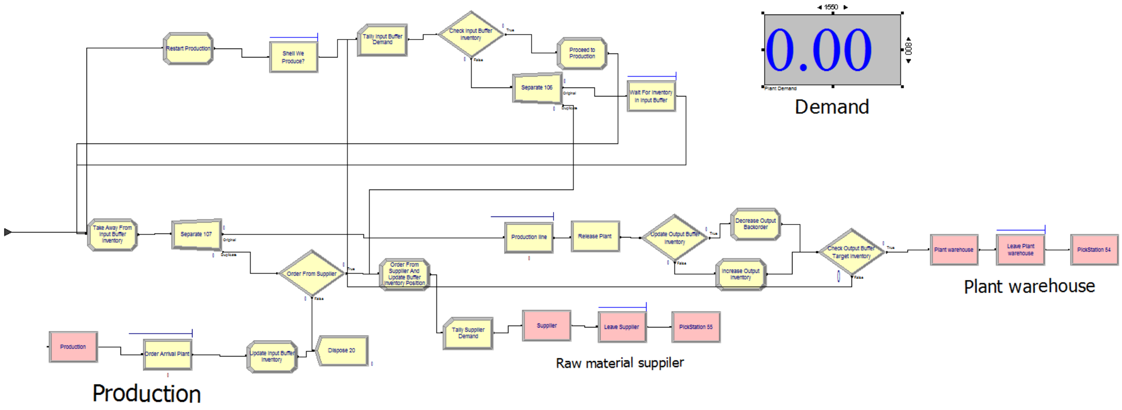


Figure 4.11: The logic for the production process

4.2.5.2.4 The result :

The expected output from the second stage of the ARENA model is the lead time. This time is the most significant variable in the relief operations. So the three levels of warehouses have been used to improve the supply chain flexibility, and a forecasting tool has been implemented to predict the demand and location of the disaster. After the model has been validated, the ARENA model output is slightly smaller than the actual data. Now, one needs to check if the forecasts and the three levels of inventory have a good impact on the lead time or not. In other words, is the lead time is less than the golden 72 hours or not. Table 4.17 shows the average lead time needed to deliver the relief material to the disaster area. As can be seen that all the lead times are less than the 72 golden hours, the proposed model is valid to improve the response time and the forecasts for the demand and location have good impact on the emergency relief supply chain .

Table 4.17 The average lead time needed to deliver the relief material

Warehouse	Lead Time/day
Africa Continent Inventory Queue	2.28
America Continent Inventory Queue	1.20
Asia Continent Inventory Queue	1.72
Caribbean Inventory Queue	0.16
Central America Inventory Queue	2.20
Central Asia Inventory Queue	0.59
Eastern Africa Inventory Queue	1.71
Eastern Asia Inventory Queue	1.78
Eastern Europe Inventory Queue	0.00

Europe Continent Inventory Queue	2.90
Main Warehouse Inventory Queue	0.50
Middle Africa Inventory Queue	0.47
Northern Africa Inventory Queue	0.00
Northern America Inventory Queue	2.59
Northern Europe Inventory Queue	0.00
Oceania Continent Inventory Queue	0.00
Oceania Inventory Queue	0.00
South America Inventory Queue	1.05
South Eastern Asia Inventory Queue	1.80
Southern Asia Inventory Queue	0.51
Southern Europe Inventory Queue	0.00
Western Africa Inventory Queue	0.65
Western Asia Inventory Queue	1.23
Western Europe Inventory Queue	0.24

4.3 Summary :

The related literature has been reviewed, which focuses on developing simulation modelling of the evacuation process in the disaster situation. Previous research findings ignore the importance of supplying the relief materials to the victims. In this chapter, ARENA simulation software is used to build an emergency supply chain model to cover this gap in the literature. Also, this model helps to study the impact of applying the JIT concept in the emergency situation. Historical data between 1990 and 2012 has been used for all type of disasters. The probability of the disaster occurrence, probability of each type of disaster, the location and the demand for each type of disaster in each country has been calculated. After that all these variables have been used to build the first stage of the ARENA model. Then a validation is done to check if the simulated values as small as the historical data or not. After that the second stage of the model is built to include the proposed model, which is the three levels of inventory level and the inventory stock. Finally, after the model is built, the result was acceptable because the lead time did not exceeds the 72 golden hours .

CHAPTER 5

Disaster Strategic Planning

5.1 Introduction

For a supply chain to succeed, strategic planning addressing long term decision making is necessary. Such choice should include location of distribution centres (e.g. localised or centralised), acquiring capital, outsourcing of non-core activities, deployment of resources, the size of the business and budgets, the effective use of the organisations' skills and corporate strategy such as warehousing and transport. It is almost certain that the economic environments and political situation in which disaster happens will define the strategic planning of relief organizations (Long and Wood, 1995).

Strategic planning classifies, evaluates and assesses the weaknesses and strengths of probable situations. A long term planning method is accepted which lets an organisation to be ready for what must be done when a disaster occurs (Long, 1997). For instance, the planning and valuation for the Asian Tsunami emergency were insufficient which caused problems in the execution of an active response. Thomas and Kopczak (2005a) and Völz (2005) highlight the difficulties that can happen if forward planning does not occur, and which may affect other CSFs such as capacity mapping, information requirements, collaboration mechanisms and coordination. Strategic planning will also contribute to relief agencies in producing more effective inventory management and may result in numerous approaches such as pre-positioning (Matthews 2005). A respectable case of successful pre-positioning of emergency materials and supplies happened in Indonesia in May 2006. Subsequent to the growing action of the Mount Merapi volcano, relief organizations were stockpiling and mobilised of aid in readiness for great scale movement of the residents and probable victims. In the re-occurrence of an earthquake of 6.2 level in the same area causing in large scale damage to buildings, movement of at least 600,000 people and the loss of an estimated 5,200 lives, relief supplies were used. Appropriateness and availability of relief resources was therefore less of a problem than is often observed.

The effectiveness of IT systems will also necessitate to be careful at the strategic planning level with an investigation of information content and movements being addressed (Gunasekaran and Ngai (2003); Soin (2004); UNDP (1993)). The strategic sourcing and centralised procuring of relief will also be important to successful distribution. The UNDP (1993) proposes that the operational and implementation parts of such plans have to be accepted and understood by everybody in the organisation.

5.2 Inventory Management

Inventory management plays an essential logistics role as other functions rotate around managing inventory. It is concerned with the 'controlling, coordinating and planning of materials flow along the logistics supply chain. Volumes, consolidation and timing are significant and will be affected by both demand and supply. Inventory management requests to address both 'in-country sources of supplies which can be accessed at small demand and existing inventory within the organisation. Inventory analysis needs to consider lead times for 'the supply of critical items' (UNDP, 1993) and forecast request along the supply chain (Gunasekaran and Ngai, 2003). As Power et al. (2003) propose flexibility both product and process are pre-requisites for being responsive and nimble to changing market requirements. Commercial companies have used many different approaches to optimize their use of resources such as JIT and some of these may be suitable for HA distribution. Inventory management in HA contrasts from normal supply chains in that 'the time values of commodities are much bigger than the inventory carrying prices' (Long and Wood, 1995). A number of HA organisations, for instance World Vision, implement a prepositioning method, by maintaining completely stocked warehouses in main locations and pre-planned stock schedules with transport companies and suppliers in a series of other countries. This contributes to an additional rapid response once a disaster occurs (Matthews 2005).

- Demand

Figure 3.2 shows the aggregate number of people affected globally due to natural disasters from year 1900 to 2011. Moreover, this trend also indicates that the number of people affected is exponentially increasing with respect to time as shown in Equation 5.1. Identifying the best fit curve indicates that the aggregate number of people reported affected is Weibull distributed with shape and scale parameters values as 0.2031 and 3.25129 E+08 (or 325 ,129,000). Future forecasts can be calculated using the exponential distribution function.

Fitted trend equation is:

$$Ft = 6326.74 * (1.1601^{t}) \qquad (5.1)$$

From the historical data the aggregate number of people affected (demand) percentage for each regional warehouse has been found as shown in Table 5.1 .

Table 5.1: The historical Average demand for each regional warehouse

Region	**Continent**	**Average Demand**	**Percentage**
Australia and New Zealand	**Oceania**	110202	1.8
Caribbean	**Americas**	98883	1.6
Central America	**Americas**	80124	1.3
Central Asia	**Asia**	108158	1.8
Eastern Africa	**Africa**	350239	5.7
Eastern Asia	**Asia**	1843138	30.2
Eastern Europe	**Europe**	111086	1.8

Melanesia	**Oceania**	27275	0.4
Micronesia	**Oceania**	7291	0.1
Middle Africa	**Africa**	43275	0.7
Northern Africa	**Africa**	151903	2.5
Northern America	**Americas**	31056	0.5
Northern Europe	**Europe**	10638	0.2
Polynesia	**Oceania**	13257	0.2
South America	**Americas**	164047	2.7
South-Eastern Asia	**Asia**	259680	4.3
Southern Africa	**Africa**	179166	2.9
Southern Asia	**Asia**	2227101	36.5
Southern Europe	**Europe**	53005	0.9
Western Africa	**Africa**	164803	2.7
Western Asia	**Asia**	53123	0.9
Western Europe	**Europe**	15544	0.3

After the demand has been found, the most important items for each person or relief recipient have been found according to (UNHCFR) . Tables 5.2, 5.3 and 5.4 show the personal need quantity per day.

Table 5.2 The Most Important Items for Each Person (UNHCFR)

Item	Qty/day/person
Food	2100 Kilocalories
Water	17.5 Liters
Land	30 m^2
Sheltered space	3.5 m^2

Table 5.3: Environmental Sanitation needed for number of people **(**UNHCFR)

Item	One/per the number
Latrine	20
1*100 liter refuse bin	50
Wheelbarrow	500
Communal refuse pit (2m*5m*2m)	500

Table 5.4: The suggestion mix of food per person per day(UNHCFR)

Items	Quantity in g/person/day
Cereal flour/rice/bulgur	400
Pulses	60
oil	25
fortified blended foods	50
sugar	15
Iodized salt	5

5.3 Transport and Capacity Planning

Transport and distribution are important in disaster aid (Long, 1997), and a significant characteristic of logistics will be the requisite to scheduling, utilisation of capacity, maintenance and address mode. The full series of activities contains outsourcing of transport, cost minimisation, payment, local tendering and brokering, consolidation, strategic alliances and contract services (Gunasekaran and Ngai, 2003). Where standing long run relief programmes are already in existence, short run crisis aid may be able to attract on currently organised logistic programmes. In disaster relief conditions aid organizations are likely to be challenging with each other for the similar transport capability and this will raise the cost as the local transport sources respond to market forces and rising costs as demand outstrips supply. Such a case was well recognized in the result of the Asian Tsunami (Thomas and Kopczak, 2005a). The full range of transport choices are likely to be required with air (mainly in the initial periods of a disaster), road and sea, right down to the use of pack animals where no further transport choices are presented Long and Wood (1995), Beresford et al. (2002).

Capacity planning is affected by both long and short term demand and will affect choices on number of warehouses and delivery centres and their capacity, number of employees, vehicles and other equipment. Four crucial areas affecting capacity are human resources, material handling devices, transport and warehousing (Gunasekaran and Ngai, 2003). Improving the capacity of relief systems can also be reached through cooperation with commercial sectors as represented by the World Food Programme's (WFP) cooperation with TPG to use their off-peak capacity (Cottrill, 2004).

In addition, capacity planning may spread to contain the capability of airports and ports to handle aid cargos under different relief situations. In respect of airport capacity, the capability to take cargo handling facilities, certain types of aircraft, helicopter operational ability, refuelling and conflict with current services, will all influence on operating capacity (UNDP, 1993). Airport capacity was put under significant stress during the outcome of the Asian Tsunami when many aid organizations sought to land their own aircraft (Thomas and Kopczak, 2005a). For ports capacity, studying ability would require to consider the kind of handling facilities existing, on-pier storage and the real functioning capacity of the port at dissimilar times of year. During the 1999 Balkan disaster port operations were changed from Macedonia to Greece, Italy, and Albania in order to overcome capacity difficulties (Gooley 1999).

5.3.1 Warehouse capacity

After determining the relief material per person, the warehouse capacity is found using the items specification according to (UNHCFR), as shown in Tables 5.5 and 5.6. Subsequently, the warehouse capacity is calculated according to the space required per tonne as shown in Table 5.7. The Typical Services and Infrastructure Requirements for Refugee Camps are shown in Table 5.8 .

Table 5.5: The relief material specification(UNHCFR)

Commodity volume per ton(m^3/1000 Kg)	**Approximate**	**standard package stacking height**	**typical maximum**	**Unit**
Water	1	none	n/a	
Food grains/beans	2	50	20-30	Kg bag
Flour and blended foods	2	25	20-30	Kg bag
Edible oil in tins inside cartons	4	20	8	Kg / carton
Mixed Drugs	3.5	45	3_4	Kg / carton
clinic equipment and teachimg aids	4.5	35-50	3_4	Kg / carton
Kitchen utensils	5	35-40	3_4	Kg / carton
Family tents	4.5	35-60	4.5	Kg/unit
compressed blankets	4.5	85	4.5	Kg/bale
loose blankets	9	1	3_4	unit

Table 5.6: Tents data (ifrc.org)

Number	**Number of people**	**Area (m2)**	**Weight (KG)**
1	5	16	64

Table 5.7: Warehouse space required (UNHCFR)

Item	Space need
Space per tonne	1.2 M^2
Tonne(Volume)	7.2 M^3
High	6 M

Table 5.8: Typical Services and Infrastructure Requirements for Refugee Camps(UNHCFR)

Typical Services and Infrastructure Requirements	Per unit
1 latrine	1 family (6 - 10 persons)
1 water tap	1 community (80 - 100 persons)
1 health centre	1 camp (of 20,000 persons)
1 hospital	up to 200,000 persons
1 school	1 sector (5,000 persons)
4 commodity distribution sites	1 camp module (20,000 persons)
1 market	1 camp module (20,000 persons)
2 refuse drums	1 community (80 - 100 persons)
Roads and walkways	20-25% of entire site
Open space and public facilities	15-20% of entire site

5.3.2 Site planning Case study :

In this section an explanation to the site planning is provided according to the previous data. It is assumed that a country wants to pre-plan to disaster situation before it happens by preparing camp according the UN recommendations so it will be ready to rescue the victims very fast. They start studying the historical data for disaster. After that, the average number of people affected has been found as for example, 150,000 people. According to this number the government plans to build 8 camps suitable for the affected number of people. The total area for the camps have been found as 5,025,000 M^2 (628,125 M^2 each), which includes 525,000 M^2 of shelter space. After that the number of tents has been found as 30,000 which need 528,000 M^2 (66,000 M^2 each) of space to build the tents . Furthermore, the size of the warehouse has been calculated for the different relief materials for a single day only as shown in the following Table 5.9 .

Table 5.9: The required area to store the relief material

Items	Volume (M^3)	Area (M^2)
Water	2625	1312.5
Cereal flour/rice/bulgur	120	60
Pulses	18	9
Oil	15	7.5
fortified blended foods	15	7.5
Sugar	4.5	2.25
Iodized salt	1.5	0.75
Total Area		**1399.5**

If an assumption is made that 30 days relief materials should be stored in the warehouse, then the area required to keep these relief materials is 44,185 M^2 (5,772 M^2 each). After that the Typical Services and Infrastructure Requirements have been found as shown in Table 5.10 .

Table 5.10: The Typical Services and Infrastructure Requirements

Typical Services and Infrastructure Requirements	The required number for each camp
Latrine	2344
water tap	208
health centre	1
School	4
commodity distribution sites	4
Market	1
refuse drums	417

There are numerous different factors that make the site planning very hard. The first factor is selecting good location which is safe, near the disaster area and easy to distribute the relief material. Also, there are limitations that can affect the process of layout and designing the camp , for example , latrine located not farther than 50M from user housings and not closer than 6M. Other example is tap stands placed not farther than 100M from user rooms. So there are many different limitations and constraints that affect the layout. The best idea to plan the layout before the disaster happens, will be to help the country to respond very fast to the new situations.

5.4 Information and Human Resource Management

Power et al. (2003) propose that the use of information technology is a pointer of supply chain's best exercise, principally if such systems join suppliers, value adding activities and customers. Information and control systems are seen as an 'important factor of implementation' for active logistics systems (UNDP, 1993). Long and Wood (1995) recommend that the controlling of information during an emergency 'is the single extreme element of success.'

Information technology assists in integrating information and activity to permit the supply chain to function more efficiently. IT systems let the provision of correct information, presentation measurement and control (Gunasekaran and Ngai, 2003). Information systems and communications are critical in monitoring aid processes and various systems have been developed both by the WFP with the International Food Aid Information System (INTERFAIS), and the UN with the International Emergency Network (UNIENET) (Long and Wood, 1995). More recently the Fritz Institute has established supply chain management software to help HA operations (Thomas and Kopczak, 2005a). The use of information systems to trace and track aid cargos has the ability to significantly develop the efficiency of relief distribution. For example, the WFP have used commercial logistics software to develop the management of its system, spare parts, vehicles and warehouses (Cottrill, 2004). Though, the shortage of up-to-date technologies for tracing and tracking relief in the supply chain is an important matter, only twenty-six percent of relief organizations have admission or access to track-and-trace software (Thomas and Kopczak, 2005a). The efficiency of an organisation will 'mainly be a role of the capability of disparate functions to collaborate by working as teams with corporate goals' (Power et al, 2003). The obtainability of qualified logistics experts to facilitate effective HA reactions is of paramount significance. Nevertheless, there is often a lack in the supply of people who have the pertinent training. A study commenced by Thomas and Kopczak (2005a) subsequent to the Asian Tsunami indicates that the numbers of people with the relevant training is top at the international level and poorest at the local level. Therefore, actual reaction is jeopardised by the shortage of skilled people in crucial locations. Aid organizations also will often only obtain the relevant human resources once an emergency happens, using several standby devices such as transfer or roster lists from other processes to meet employment needs on a short run basis.

5.5 Continuous Improvement and Collaboration

It is recognised that if supply chain keys are to meet the demands of the market place organisations we need to focus on having a holistic and continuous improvement absorbed method to meeting the requirements of the customer (Power et al, 2003). In this situation metrics and tools can be used to manage and improve performance, tracking key elements in supply chain performance and benchmarking the actions of an organisation in contradiction of significant performance pointers

(Korpela and Tuominen, 1996;Soin, 2004). There is no aim to trust that HA organisations could not learn from this method and for instance, by implementing IT performance measurement systems which quantify the efficiency of the supply chain could be better (Thomas and Kopczak, 2005a). Collaboration is seen as being a main differentiator in supply chain best exercise and in attaining integration and effectiveness in well-organized logistics systems (Power et al, 2003). Collaboration within the HA supply chain can effort in a number of methods. The significance of having nearby supplier relationships has received support and collaborative bidding, can assist to lower procurement prices (Soin, 2004). Relief organizations may collaborate with commercial logistics companies in order to develop the efficiency of their delivery networks. Examples contain the WFP which has been using such a preparation to restructure both the delivery network so that it more closely reflects the requirements of international HA and the use of its warehouses to improve capacity (Cottrill, 2004) and the American Red Cross which uses commercial logistics suppliers in many disaster situations (Gooley 1999). Where partnership happens,Thomas and Kopczak (2005a) specify that the consequence is usually positive. Cooperation can occur with a multiplicity of organisations including the private sector, relief agencies, the military and local authorities.

Teamwork often only happens once a disaster is unfolding and it is then much harder to optimise coordination. This hints to situations for instance in Banda Aceh in 2005 where missing any normal working techniques or common accepting of the parts each would play, on-site management and coordination among the humanitarian relief organisations was not optimized, challenging supply chains for transportation and procurement affected bottleneck at local roads and airports, demanding already narrow capability. While the direct requests of a disaster can be met by ad hoc partnership longer term needs are less well served and more ‘appropriate mechanisms’ would develop reaction efficiency (Thomas and Kopczak, 2005a). In the direct result of the Tsunami there was significant inter-agency ‘squabbling’. This was resolved resulting into cooperation happening. The resolution of such difficulties pre-disaster would have confirmed that the direct reaction was that much better (Völz, 2005). This one instance highlights the statement that poor partnership can have an influence on a number of other success factors counting transport, inventory management, and capacity planning.

5.6 Technology Utilisation

While new technologies are frequently seen as a method to develop supply chains, suitable and more active use of present technology should not be ignored (Power et al, 2003). Communication is a significant feature of any relief process and utilising current communications infrastructure is as

essential as other telecommunication approaches (Gooley 1999). Real time communications are 'the most important method of reacting quickly for effective coordination' (Long, 1997).
During the initial phases of the Asian Tsunami response, eighty three percent of organisations were connected by satellite phone or cellular and it was not until a week into the disaster that fifty percent were using email. Trusting one type of communication can however make problems as heavy usage and may generate communication difficulties (Thomas and Kopczak, 2005a).

5.7 The proposed Emergency supply chain work flow with CSFs :

The proposed procedure is divided to in two parts, the first one is protection and preplanning and the second is response and support. The first part includes partnership between people and community within the policies and standards, also how to deal with data such as data verification and data storage. After data the disaster management will take the valid data and partnership to mix it together to prepare for the disaster. They will start making the plan and arrange with suppliers to be ready for any type of disaster according to historical data, for example what is the demand, items need and so on. After that they will start the controlling inventory, for instance, the ordering strategy, what is the optimal order quantity, and when to order. Then, they will start calculating the required budget to apply their plan and try to find fund and donation to accomplish the desired plan. In this stage the improvement of the previous plan will happen by taking the feedback from the victims and other organization. This improvement has two parts, one of them is the procedure of work for example how to improve to communicate between the team and the victims or the distribution of relief material and so on. The other part is improving the technical method with the new technical problem from the real situation by suggesting different engineering solutions. This will cover the Continuous Improvement and Collaboration part which make the emergency plan active and update with any type of possible problem which happen during the relief operations.
The other part is when the disaster happens. The implementation time to the emergency disaster plan is start time. The idea is the proposed flow that the plan will update continuously with the cooperation between three teams working together at the same time. The first team is NGO's and government, the second team is volunteer technology group and the last team is the disaster victims. The mission of each group and how each group cooperates is discussed here. When the disaster happens the teams start their work; the NGO's and government team will start making assumptions about the disaster situation for example number of people affected, relief material needed, and so on. After that, they will start the next step by selecting the facility location to distribute the relief to victims in easy and fast way. Then, they will start contacting suppliers, which they arrange with them before the disaster happens. The suppliers will start distributing the ready items and start producing the reset quantity. The second team has three main missions: (1) Data

analysis, (2) Interface between the local and international humanitarian organization, and (3) communicating with the victims. With the data analysis mission the volunteers collect the actual data from the disaster area and start analysing it. Then they will update the assumption that the NGO's and government team considered in the first stage by providing them with the real data so they can deal with the time varying relief demand. The volunteer technology group team will start providing the required materials by making categorization and pinpointing on an interactive map to locate the coordinate to NGO's and government team so the response time will be shorter. Also, they use the media and the SMS to inform the victims about the situation. The last team plays important role in the relief operation by using mobile application which helps them to interact on the interactive map. Moreover, the victims in the disaster area know the area well so they can provide the relief teams good information about how to distribute the relief material in an easy way. Furthermore, they can provide them with alternative distribution way if the main one is distorted due to disaster. After the disaster finishes, the NGO's and government organization will wait for the feedback from the three teams to modify and improve the emergency response plan in order to improve the readiness for the next disaster. Figure 5.1 shows the proposed emergency supply chain flow, how the components work together to improve the emergency supply chain and reduction of the response time for the operation.

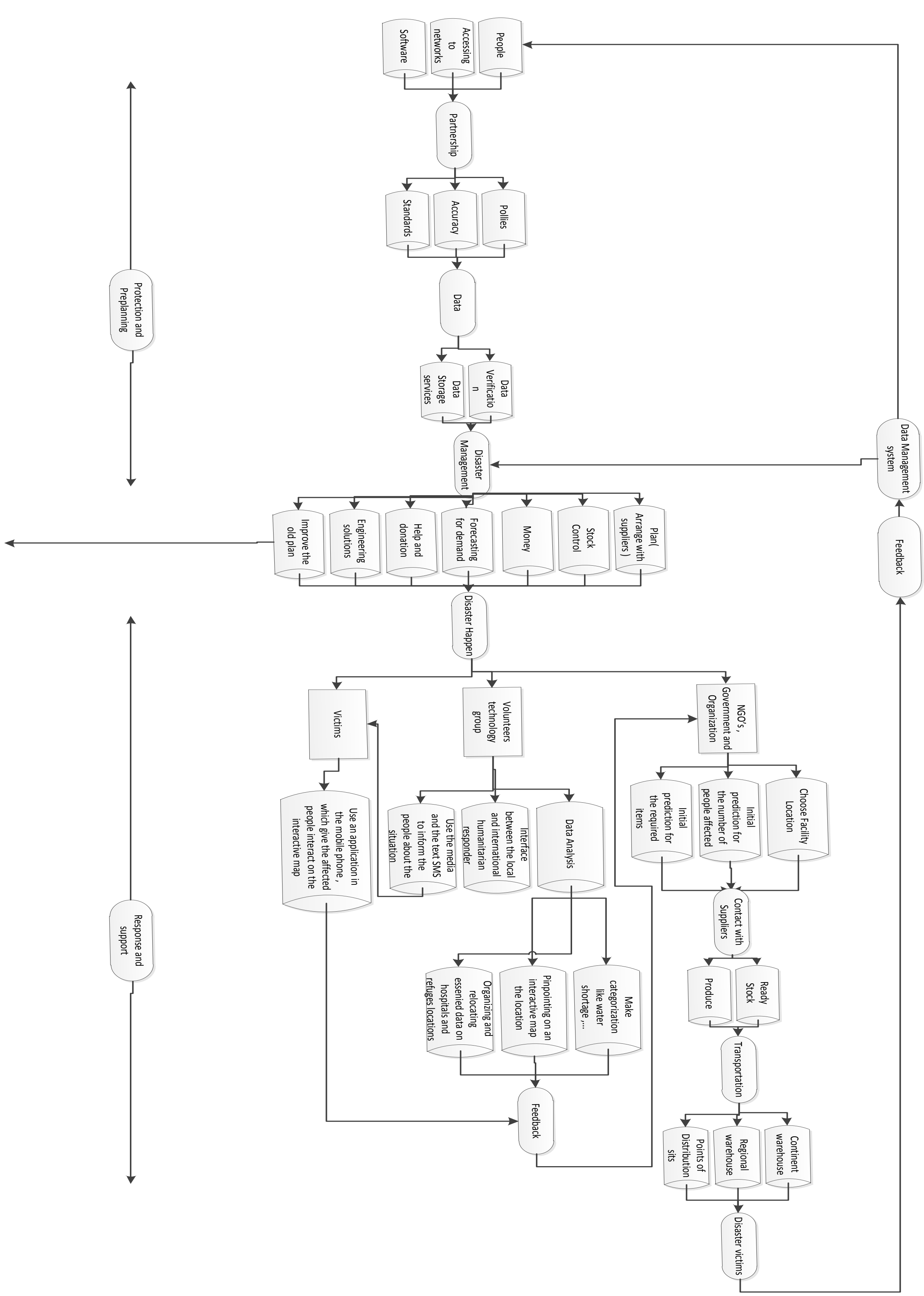


Figure 5.1 The proposed emergency supply chain flow

CHAPTER 6

Reducing the Impact of Natural Disaster in Global Supply Chain

6.1 Development of global supply chains

Driven by investment liberalization and trade and continuous cost reduction pressures from the client, companies have been spreading globally to extract the most of each location's comparative benefit. Many businesses have accepted highly integrated worldwide supply chains in which goods are delivered, manufactured and distributed cross a nationwide limitations through outsourcing policies and offshore actions. Simultaneously, markets of scale have driven the group and merging of organizations in the supply chains, which have also encouraged logistics partnership. Consequently, supply chains are becoming more complex with broader geographic attention, which has improved the visibility of the supply chains.

Offshore actions mention activities that use facilities placed in a country other than where the enterprise is built (integrated) and can contain service, sourcing and manufacture (Vitasek, 2006). The motivation for offshore actions has mainly been cost, containing lower labour, operation and current costs, higher cost proficiency with bigger manufacture scale, and may be lower financial costs, for example, tax rates and borrowing costs. For instance, offshore actions are the foreign manufacturing network of Toyota. As shown in Figure 6.1 , Toyota conducts its industry in 26 countries and areas, with 50 foreign industrial processes. As of 2011, Toyota's automobiles from these manufacturing bases were delivered to more than 170 countries and states (Toyota, 2012).

Figure 6.1. Overseas production network of Toyota (Toyota, 2012)

Outsourcing exemplifies one of the extreme modifications to global business application. Today, companies do not just get parts and materials from overseas merchants, but also subcontract many tasks such as logistics services and product design. The logic behind this style is that outsourcing can allow businesses to emphasise on their main value added actions, where they have a separate benefit. Overall efficacy rises because every firm in the supply chain can maximise its competitive benefit through deliberately focused reserve distribution (Christopher, 2011). Therefore, the supply chain develops a web connecting service suppliers and multi-tier providers. Main firms are at the centre of a global manufacturing network such as international supply chain, connected with numerous interrelated but independent units.

Because of outsourcing, to take benefit of the lower costs in each place in addition to enter untouched overseas markets, supply chains have been lengthy from one side of the world to the other (Christopher et al., 2011). As designated in fragmentation model, a complete production method is now divided into discrete nodes in different places (Jones and Kierzkowski, 1990). These manufacture nodes are linked by supply relations, which refer to actions organizing the process between these nodes such as warehousing, transportation, administration and financing between participating organizations (Jones and Kierzkowski, 1990). The last products are manufactured across the limitations and then traded outside the borders to clients globally. Unlike a national supply chain, a worldwide supply chain includes shipping large quantities of supplies through long distances, which raises the occurrence of using multimodal delivery facilities. Figure 6.2 exemplifies national and cross-border supply chains.

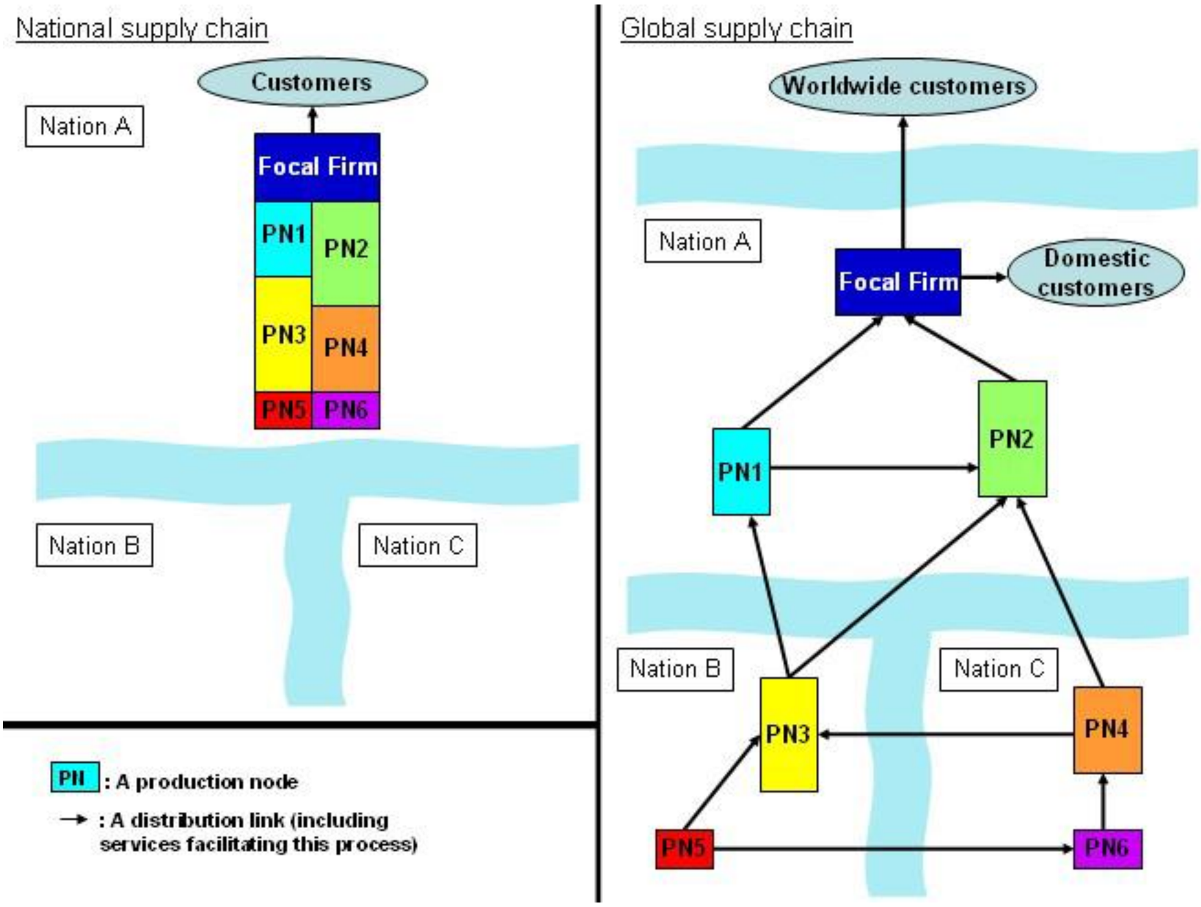


Figure 6.2. Comparison of national and global supply chains(Linghe and Masato, 2012)

Additional recent trend is the supplier merger, which mentions the decrease by organizations of their total number of merchants while increasing business with single suppliers (Economist Intelligence Unit, 2005). In some cases this trade policy has been extended to “single sourcing” whereby one provider would supply one commercial input (e.g. module, component or a part). With this policy, principal firms’ goal to build robust corporations with their suppliers and reach price benefits from the economies of scale and trading power while using suppliers’ skill in research and development (R&D), delivery, manufacture and design. It also lowers operation costs, with less order to be achieved by the principal partnerships. An example of provider merging can be seen in the automobile business, in which the figure of automotive parts providers fell from over 30,000 in 1998 to about 4,500 in 2008 (KPMG, 2009). Mergers and acquisitions (M&A) between main suppliers have facilitated provider consolidation. A related trend is manufacture agglomeration, which mentions the geographical attentiveness of production services and actions (Healey and Ilbery, 1990). Firms in the identical business tend to locate themselves very near to one another, leading to geographical attention of the manufacturing. The manufacturers of similar products locate in close immediacy to each other so as to decrease production costs. Manufacture agglomeration is also determined by economies of scale. Agglomeration in a specific location is also normally related to convenience to natural assets for example sunny climate or petroleum or low cost labour or due to favourable business situations in that place. This process also improves collaboration between firms, improvement of manufacturing estates and clusters. Provider consolidation and manufacture agglomeration have also resulted into greater than before the importance of certain manufacture bases in the supply chain, which deliver essential provisions and commercial and logistics connected services.

In order to be near to logistics services and transportation and to lower transport costs, manufacture centres are often recognized and established in coastal regions and river basins with high number of people concentrations (Clay and Benson, 2005). The advantages derived from manufacture agglomeration contain information input distribution, lower product shipment costs, spill-over and labour market (Rosenthal and Strange, 2001). Another trend is logistics consolidation, which mentions the grouping of two or more batches in order to get lower transportation costs. For instance, components and inputs from a number of providers for one production site can be pooled into a single distribution rather than each merchant supplying small amount alone. This allows the providers to segment the costs of administration, warehousing and transportation.

This trend has been attended by the emergence of third-party delivery and logistics companies, containing different turnkey service suppliers focusing in providing an in-bound consolidation facility (Christopher, 2011). The development of the worldwide supply chains joint with logistics consolidation has also improved the requirement of supply links on selected global delivery facilities containing transport arrangement, communication infrastructure and logistics systems. However, restructuring supplier consolidation, production agglomeration and production linkages have improved the position of certain suppliers and locations by focused physical properties and production services. The organization of the supply chains is becoming more difficult, with more single production nodes and delivery links involved across borders. Therefore, it has become more difficult for main firms to categorize the risks in the supply chain.

6.2 Supply chain disruptions and increasing risks

A supply chain disturbance is definite as a main failure in a production node or a delivery link that is part of a supply chain. Natural catastrophes are one reason of disruptions to supply chains. They usually consequence in widespread damage to several facilities and companies at the same time. This has a severe influence on a manufacturing and important time is often essential for recovery from natural disasters. With the globalization of supply chains, the experience of companies to risks of disasters has been extended across national limitations as a natural disaster in one physical location can also disturb companies in other locations. Also, with outsourcing and offshore actions, the level of interdependence between businesses has improved, which has increased susceptibility because disturbance of even one part of the worldwide supply chain can result in working breakdown of the other parts. Though the principal firm may be able to identify some disaster-prone nodes or relations within the supply chain, fragmented manufacturing has reduced the degree of monitoring and control of the focal firm over production nodes and delivery links (Kimura and Ando, 2005).

At the same time, with provider consolidation and manufacture agglomeration and resulting high density of production possessions and economic actions in confident locations, the risks have been centralized in those locations. When disasters disturb areas where manufacture facilities are focused (mainly those located in regions vulnerable to flooding and storms, such as coastal regions or areas near to rivers), supply chains are interrupted, which results in important structural losses to the full production network and even to connected businesses. During the catastrophe and recovery period, other businesses in the supply chain may happen stance difficulties in discovery correct substitute providers or customers elsewhere, making the influence of the disaster last longer. Moreover, dependence on global delivery services has improved vulnerability to disaster as destruction to these facilities can easily lead to supply chain disruption.

Some generally adopted supply chain management policies also raise the risks of problems in circumstances of natural disasters. Instances contain the lean supply chain management and "just-in-time" practice, which need more recurrent distributions of supplies, reducing the non-value-added time and inventory. These efficiency growth models in business increase the level of interdependence between companies and consistently raise the probabilities of a supply chain disruption. Also, the density of non-value-added time in inventory transfer and storage may eliminate the critical risk buffer among the production nodes and deepen the harmful effect when natural hazards happen in the worldwide supply chain. For instance, when a disaster happens a provider or a delivery link interrupts the supply chain, the focal firm that approves "just-in-time" practices will unexpectedly encounter production postponement due to supply shortages and the negative consequence will transmit rapidly to the downstream supply chain.

In addition to the damage due to direct loss and retrieval cost, natural disasters may reason cash flow difficulties among contributing firms if the partners in the supply chain cannot resolve their payables in time, and thus pose threats to the financial condition of a firm. Negative financial positions may raise the concerns of financial institutions and pose problems for firms in finding external financial capitals during the recovery stage. If the firm is publicly traded, a supply chain disturbance may negatively influence their standing and cause deficit in the market (Hendricks and Singhal, 2005). Financial organizations can also be precious by interruptions to the supply chain affected by natural disasters. Furthermore to losses in the insurance industry, financial difficulties of customer firms caused by catastrophes and the following supply chain disruptions may make unpredicted problems in the repayment of loans and in turn undermine the stability of financial organizations.

A growing number of small and medium-sized enterprises (SMEs) are elaborated in worldwide supply chains. SMEs are usually providers of labour-intensive components and parts or suppliers of other simple services, generally on a subcontracting basis (Abe, 2012). Larger partners in the universal supply chain often take benefit of the bigger flexibility of SMEs and their flexibility to local economic situations and capacity to function orders for smaller quantities, but SMEs have been recognized as an extremely disaster-vulnerable group in the supply chain. The small market share and weak trading power of single SMEs places them in a disadvantaged situation in negotiations with supply chain partners to find assets and support to deal with the effect of disasters. Lack of output modification also bounds the capability of SMEs to cope with demand and supply shocks and market volatility created by disasters. Studies have shown that few SMEs are sufficiently prepared for natural hazards. SMEs have been recognized as the top segment of underinsurance, and they generally do not follow behaviour risk assessments or appliance business continuity strategies (CERNO, 2010;Charted Insurance Institute, 2009). This lack of planning consequently raises the difficulty of recovery from disasters and the following supply chain distractions (Wedawatta et al., 2010).

6.3 Case studies: Japan earthquake and Thailand floods

The natural disasters that happened in Japan and Thailand in 2011 were among greatest disturbing in the Asia-Pacific area in current history. In March 2011, an enormous earthquake, known now as the Great East Japan earthquake, hit the northeast area of Japan and was followed by shocking tsunami. Then, in late 2011, floods in Thailand affected enormous damage to the country. Given the significant positions of Japan and Thailand in the worldwide supply chains for several economic sectors, the two disasters produced large distractions both nationally and globally, thus highlighting the interconnected nature of economies and world markets.

The two cases highlight the different kinds of effects of natural disasters on the worldwide supply chain. Japan not only performs as a main provider in many industries such as, steel, electronic parts, chemicals and automotive parts, but also as a manufacturer of end goods to the mass market. Consequently, the Great East Japan earthquake impacted together upstream providers in developing countries and end clients in developed countries, as both supply flows and demand signal were severely interrupted. In contrast, Thailand is a main provider in the international supply chain, mainly in the electronic and auto sectors. Therefore, downstream partners in the supply chain were adversely affected by the catastrophe as they were unable to source components and parts from Thailand in the flood.

6.3.1 The Great East Japan earthquake

The earthquake which hit Japan also, led to the breakdown of nuclear devices in Fukushima. The disaster affected a record 210 billion Dollars (USD) in economic loss, representing 3.8 per cent of Japan’s Gross Domestic Product (GDP) (EM-DAT, 2012). Manufacture sites in affected coastal regions experienced one and half times as much loss as inland parts (Okada, 2011). The mixture of the tsunami and earthquake damage and the failure of the Fukushima nuclear devices affected general areas and triggered severe damage in numerous sectors, mainly in the manufacturing and chemical businesses. Because of this disaster, individual companies suffered enormous direct losses, and the disaster could have a long term influence on the ability of firms to produce and distribute their goods or services. Some companies, although they were not affected directly by the tsunami and earthquake, experienced the disaster effect indirectly because of damaged groundwork in the country. The power resource in the northern part of Japan was harshly disturbed caused by the failure of the Fukushima nuclear power plant. Consequently, the production of several industrial plants festered (Davis, 2011). Also, many railways and roads were destroyed and almost all main sea ports in the affected regions were closed (Wassener and Nicholson, 2011). This reduced the movement of final goods, raw materials and components, thus causing various supply chain troubles.

The disaster also created some effects on human capital and the worker market. In the directly-affected area, the number of requests for unemployment insurance increased sharply in the first few months (Berkmen et al., 2011). The catastrophe also had a national impact on the labour market due to increased insolvencies and loss of work. Furthermore, the disaster required a reorganization of human capital to different geographic locations and industrial parts (Kirchberger, 2011). As a result, gaps between labour supply and demand in terms of skills and quantity further raised unemployment.

In reply to the disaster, the Government of Japan applied a number of employment endorsing programmes, for example "Hello-works" and the "Japan as One" work project, to assist job matching and job creation (Ministry of Heath Labour and Welfare, 2012;Rokumoto, 2012). Consequently, affected businesses, mainly those in the industrial sector, quickly recovered their levels of employment, as they were working to improve their manufacture to the level previous to the earthquake and tsunami (Thompson, 2012).

6.3.1.1 Chemicals supply disruption

The disruptions affected by the catastrophe in Japan strongly affected some supply chains, mainly those that trust on a single supplier or few sources for some inputs. For instance, Ethox Chemicals, an American chemical international, depends on an important material provided by only three firms in the world, one of which is placed in Japan. After the catastrophe in Japan, Ethox was hurt due to supply unavailability as the other two providers in Malaysia and Europe were not able to make up for the supply slowdown in Japan.

Another example of the disruptions affected by the catastrophe in Japan in chemicals industries. Xirallic pigments, Specialty paints, were amongst the first automotive inputs to be precious by the Japan catastrophes because the individual plant in the world that produced them, owned by Merck Chemicals International of Germany, is close to the Fukushima nuclear device. According to the producer, Xirallic pigments produce "a stronger glitter effect than with all the other pigments. Lighter body color, greater color intensity and a more powerful luster are the advantages. (Merck Chemicals International website, 2012)," Though the Merck Chemicals plant has started again manufacturing, "the closure of the plant affect several of the world's automakers, containing BMW, GM, Toyota , Ford, Volkswagen and Chrysler. Consequently, the new cars the world over became a little less shinier" (The Truth About Cars, 2011). Chrysler broadcast to merchants in April that 10 paint colors for cars were in the short term unavailable. Ford made a similar stop on some paint colors, stating that it was working on changing source which would allow it to restart production in June or July of cars painted in "tuxedo black" and three shades of red. Honda and Hyundai said they would change Xirallic pigments with other paints.

6.3.1.2 Electronics supply disruption

Japanese electronics providers affected by the disaster contain Panasonic, Hitachi, Toshiba, and Renesas. Renesas Electronics is one of the main worldwide car chip makers, manufacturing as much as 40% of the world's quantity of automotive microcontrollers at a firm disturbed by the earthquake. According to a New York Times investigation, a reason for the industry's full dependence on Renesas is that it is the creation of mergers containing three Japanese semiconductor firms. Mitsubishi Electric and Hitachi merged their semiconductor processes in 2003 to form Renesas Technology. Then, in 2010, NEC Electronics merged with Renesas Technology (New York Times, 2011b). The Renesas plant was out of order till mid-June and then, when it started again manufacturing, would work at only about 10% of capability for an undisclosed period of time. It relocated manufacturing to Renesas plants in northern Japan and Singapore, but that took some months. It took two months to manufacturing the chips, which means it was at least four months before manufacturing met orders (Automotive News, 2011a). Another big car chip manufacturer is U.S.-based Free scale Semiconductor. Its Japanese firm close to Sendai was so damaged that Free scale is not going to renew it (Freescale, 2011), because so much of the auto manufacturing's supply chain is adapted for specific makes and parts, models like the microcontrollers that are unexpectedly in short supply are not simply found elsewhere. The software that teaches the chips in their tasks is also not standardized, so even if an automaker could discover a replacement chip rapidly, it might not be able to connect with the car's software programming.

- Earthquake damage of Renesas Electronics Corporation

The corporation's Naka Plant and other industrial facilities were strictly hurt by the earthquake. Moreover, to the cost for repairing smashed properties, Renesas had to set of losses stock and other fixed resources as well as pay the loss of leasing agreements. It also needed to cover fixed costs in vindictiveness of manufacture breakdown. Table 6.1 presents the corporate losses to Renesas caused by the earthquake.

Table 6.1. Losses for earthquake damages in 2011, Renesas Electronic Corp

Items	Amount (USD millions)
Repairs to property , plant and equipment	535.8
Loss on disposal of stock	90.7
Loss of disposal of fixed assets	77.1
Fixed expenses during suspension of operations	73.3
Loss on cancellation of lease contracte and others	37.3
Total loss on the disaster	**814.2**

With the hurt to Renesas Electronic Corp, the major producer of custom-made microchips in the world, the entire automotive manufacturing in Japan and the other location of the world experienced severe manufacture delay, because the user-specific chips were hard to re-source and the constricted "just-in-time" management in the industry caused in very low inventory, generally for up to only six hours (Endo, 2011).

As the economy of Japan is enormously linked into the world economy, the indirect and direct supply distractions affected by the disaster were practiced globally. After the Great East Japan earthquake, Japanese automobile production and electrical parts production dropped by 47.7 per cent and 8.25 per cent, correspondingly (CEIC, 2012). As Figure 6.3 exemplifies, the impact of the Japanese disaster spilled over to other countries in the area. This was most visibly evident in the cases of Indonesia (-6.1 per cent), the Philippines (-24 per cent) Thailand (-19.7 per cent), for automobile manufacture, and Malaysia (-8.4 per cent) and the Philippines (-17.5 per cent) for electrical part production. Disruptive effects from the Great East Japan earthquake had a big influence on the automotive area (about three months) than on the electrical segment (about two months).

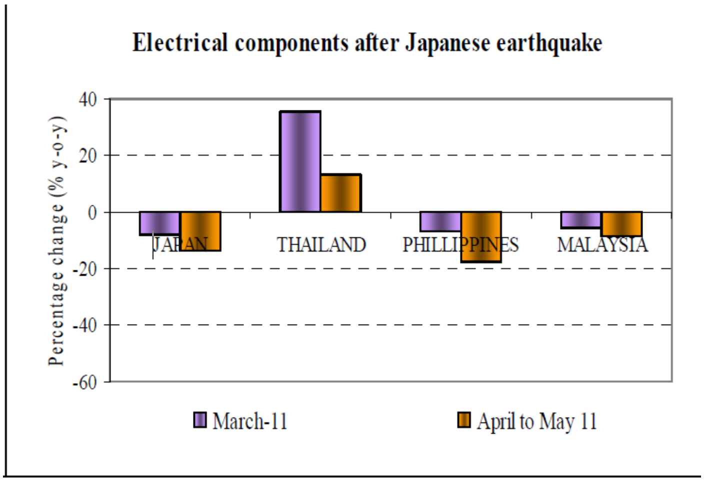


Figure 6.3. Disaster impact spill-over from the Great East Japan earthquake (CEIC, 2012)

6.3.1.3 Steel supply disruption

Japan is the world's second main steel manufacturing country. It made 109 million metric tons of steel in 2010, which is amid the world's top three iron ore traders. The country accounted for about 12.8% of worldwide iron ore cargos in 2010. Also, Japan was the second main trader of steel in Asia in 2010. It shipped 43 million metric tons of steel. Japan's five main steel manufacturers account for about 80% of the country's steel manufacture capacity. Most of their productions are placed near the Osaka Bay, Hakata Bay, and Tokyo Bay.

- Affected Steelmakers

The tsunami and the earthquake forced some Japanese steelmakers to temporarily interrupt processes on March 11. However, by March 13, many of these steelmakers restarted operations.

Nippon Steel's Kimitsu part was briefly out of business for inspection. Two out of its three boilers were resumed following the assessment. Nippon Steel publicized that the processes of its Kimitsu unit have been restored to pre-earthquake points. The Kimitsu component manufactured 5.9 million tons of crude steel in 2010.

Sumitomo Metal Industries Limited's coke oven gas storing part in Kashima, Ibaragi caught fire on March 11. The fire was quenched by the next day, March 12. The unit's two blast heaters were blanked indeterminately and were checked for damage. One of the furnaces was resumed on March 20; but, the second furnace probably took some days for processes to restart. The Kashima component produced 5.7 million metric tons of crude steel in 2010.

Tokyo Steel broadcast that it would resume its processes only after checking that all of its facilities would not have experienced any damage.

The Kanto plain area has 18 electric steel manufacturers: Godo Steel, Kanto Steel and Tokyo Steel Manufacturing. It produces 400,000 metric tons of crude steel per month. The downstream manufacturing for this production is largely construction.

Electric steel mills have been pretentious by the power limiting affected by Tokyo Electric Power. The manufacture of these mills fell due to the power limitations. Both of Itoh Steel's mini mill and Tokyo Tekko's mill in Hachinohe were flooded, which produced 200,000 metric tons and 170,000 metric tons per year.

- Impact on Steel Markets

Domestic Market

The earthquake and the tsunami damaged thousands of factories, schools, and homes. The ports in Ishinomaki Hachinohe, Sendai, and Onahama caused heavy harm and took months for rebuilding. The reconstruction of groundwork in the tsunami and earthquake stuck area was assessed to cost about US$ 180 billion. Almost 10% of this rebuilding cost was for steel. Renovation consumed 30 million metric tons of steel in two years past-disasters.

Japan's Ministry of Land, Infrastructure, Transport, and Tourism had requested businesses to use kit homes and emergency housing to raise their production to help accommodate the approximately 390,000 people who became homeless. The growth in the manufacture of emergency housing consequently increased demand for building steel products. Though, demand was not predictable to pick up directly as there was uncertainty nearby when the rebuilding efforts were created in Japan. Renovation after the Kobe earthquake that stuck Japan in 1995 lasted only two months after the quake hit.

Japan's industrial production was also affected in the short term due to the power supply limiting applied by the Japanese government. For instance, reduced power had decreased the production of the automobile manufacturing. In the short period, the fall in output from the engineering industry resulted into a short-term fall in the request for steel. The country's manufacturing industry used 65% of steel in Japan. But, the power restricting applied by the Japanese government did not influence the steel production of large manufacturers. Companies such as Nippon Steel is 90% self-reliant in its energy demand requests. J. FE Steel has in-house power producing capacities to meet 95% of its power requests. But, the small mills that function electric boilers were affected by power limiting.

International Market

The import of the Japanese steel by the steel imports of Malaysia, Singapore, China, Thailand, Indonesia, Taiwan, and South Korea was noted. These countries imported 78 million metric tons of steel goods in 2010, out of which steel goods from Japan made up about 40% of their total imports, as shown in Table 6.2 .

Table 6.2. Losses for earthquake damages in 2011(CEIC, 2012)

Country	Percentage
South Korea	45%
China	47%
Thailand	40%
Taiwan	44%
Indonesia	24%

The rebuilding of groundwork in Japan needed an enormous amount of steel. Once the renovation process started, much of the steel manufactured in Japan was focused to reconstruction efforts. As a direct result, steel exports from Japan reduced.

Supply chain distractions and corresponding manufacture stagnation in numerous industries, mainly export-oriented industries, emphasized the risks of losing worldwide market segment. For instance, in the steel manufacturing, Posco, the world's third biggest steelmaker by production, according to the Republic of Korea, increased a segment in the market for materials for shipbuilders in the area, switching Japanese steelmakers (Narayanan, 2011).

6.3.1.4 Automobile supply disruption

The result of these catastrophes has been first and leading borne by Japanese automakers, which shutdown several of their Japanese assembly firms for some weeks as they evaluated their supply chain matters and influence on their Tier 1, 2, and 3 providers. Japanese automobile plants in other areas of the world have also been influenced, including facilities owned by Honda, Nissan, Toyota, and other companies in the South and Midwest of the United States.

Located in the disaster area and unfavorably affected by these forces are a number of manufacturing plants which are integral to the worldwide automobile supply chain. They contain plants that collect automobiles and many providers which build components and parts for vehicles. Several of the Japanese plants that were forced to stop deliver chemicals and parts are not simply available elsewhere. This is mainly true of automotive microchip technology, a major manufacturer which was placed close to the center of the destruction.

IHS Global Vision, a worldwide consulting firm, predicted that over 4 million elements of vehicle manufacture would be lost as a result of the catastrophes in Japan, with 90% of them from Japanese cars.

The supply chain disturbances in the automobile manufacturing in Japan triggered by the earthquake caused in a severe shortage of mid-sized and small cars in the global market in addition to decreased automobile manufacture in Europe and the United States of America, which depended on Japanese providers of parts (Snyder, 2011) Consequently, less affected automakers increased shares in the worldwide market, at least in the short term (General Motors, 2012;Toyota, 2012). Data show that Toyota was left behind by General Motors as the world's main carmaker by volume in 2011.

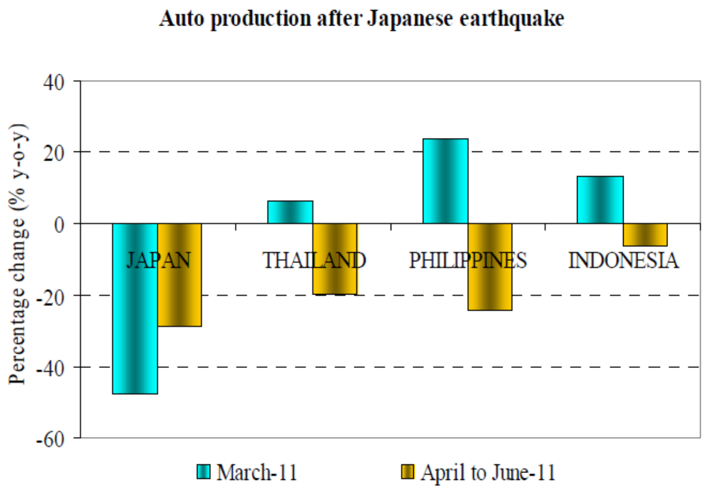


Figure 6.4. Disaster impact spill-over from the Great East Japan earthquake (CEIC, 2012)

- Impact on Automakers

The March 11 catastrophes temporarily shutdown the firms that produce 17 of the best 20 types of Japanese cars traded in the United States and encouraged General Motors to stop a plant in Louisiana and Peugeot a firm in Europe (Automotive News, 2011c). Japan's motor car industrial facilities are not focused in one part of the country, but are variously placed on the core Japanese island of Honshu. Greatest manufacture takes place southwest of Tokyo, far away from the epicentre of the earthquake (The Truth About Cars 2011). The seaside part affected by the natural catastrophes, Toyota and Nissan operate assemblage plants in Miyagi and Fukushima prefectures, correspondingly.

On May 10, the government of Japan broadcast that additional nuclear plant would be shutdown due to its vulnerability to an upcoming earthquake. The Chubu plant is more deliberately placed in Japan's auto-producing area southwest of Tokyo. Its shutting will disturb power available to half of Toyota's Japanese facilities, all Suzuki's plants, and some Mitsubishi and Honda car plants (Reuters, 2011). IHS Global Insight, a global economic and financial consulting firm, has predicted the influence of the disasters on cars manufacturing. It predicted distractions lasting into the end of year 2011, with aggregate manufacturing for Japanese automakers in Japan reduced by as much as 2.2 million parts that year and for Japanese automakers outside of Japan dropping by as much as 1.6 million units. These were large decrease. The Japan Automobile Manufacturers Association, Japanese carmakers in 2010 manufactured 8.3 million cars in Japan and 13.2 million outside of Japan (JAMA, 2012). IHS also considered non-Japanese automakers outside of Japan losing about 450,000 units that year because of disaster in Japan, carrying the total of lost manufacturing to 4.2 million units internationally (Michael, 2011). IHS's prediction of lost car manufacture capacity is shown in Table 6.3. Table 6.4 is surmising the impact of Japan earthquake on different car producer .

Table 6.3 Effect of Japan Disaster on World Vehicle Productions
IHS's prediction of lost car manufacture capacity

Time Frame	Production Location	Production Decline from Jan.-Feb. 2011 Run Rate
April	**Output in Japan**	-80%
	Japanese automaker output of outside Japan	-15%
	Global output	-13%
May	**Output in Japan**	-41%
	Japanese automaker output of outside Japan	-33%
	Global output	-16%
June	**Output in Japan**	-31%
	Japanese automaker output of outside Japan	-21%
	Global output	-11%
July	**Output in Japan**	-24%
	Japanese automaker output of outside Japan	-12%
	Global output	-7%
August	**Output in Japan**	-20%
	Japanese automaker output of outside Japan	-4%
	Global output	-3%

Source :"IHS Global Insight ,"Japan Disasater Output Impact Update." April 28 ,2011 p.5 .

Table 6.4 Surmise the impact of Japan earthquake on different can producer

Company	Reason to reduce production	References
Toyota	because of continuing parts availability issues for those models and plant limitation in Japan. Tyota produce 45% from Japan	(Automotive News, 2011e),
Nissan	because of continuing parts availability issues for those models and plant limitation in Japan. Directly affected by the earthquake/tsunami was the company's plant at Iwaki, where engines for popular models such as the Murano, Infiniti, and Z350 sports car are built. Nissan produce 33% from	(Automotive News, 2011d)

	Japan	
Honda	because of continuing parts availability issues for those models and plant limitation in Japan. Honda produce 26% from Japan	(Automotive News, 2011b)
General Motors	shortage of mass air flow sensors made by Hitachi	(New York Times, 2011a)
Ford	shortages of Xirallic-based paints	(Wall Street Journal, 2011)
Chrysler	shortages of Xirallic pigments paints	(Associated Press, 2011)

6.3.2 The 2011 floods of Thailand

In the second half of 2011, severe floods caused hefty loss in a number of South-East Asian nations and the Sindh area of Pakistan. Thailand experienced mainly severe flooding between June and December 2011, producing over US$ 40 billion in damages, losses and obstructing the country's industrial capacity. The flooding in Thailand was credited to different reasons, counting a mixture of deforestation, poor floodwater management systems, lacking urban organization and failure of previous master strategies on flood modification. One of the main negative influences of the floods in Thailand was in the situation of the worldwide supply chains. As a result of globalization, Thailand's economy has been joined into international supply chains and now has a significant place in them, as shown by important inflows of foreign direct investment (FDI), great amount of export actions and widespread activity by multinational corporations (MNCs) (Chongvilaivan, 2012).

Driven by pressures to decrease costs, companies and providers in Thailand tend to cluster in a small number of manufacturing places. Partly because of insufficient urban design, seven manufacturing estates in the provinces of Pathum and Ayutthaya Thani had been constructed on low-lying property. These business estates were harshly flooded, causing in big industrial production losses, averaging 29.4 per cent, from October 2011 to January 2012 (CEIC, 2012). Furthermore to the direct losses because of physical asset destruction, several companies suffered from supply chain disturbances. These disruptions also affected organizations whose physical assets were unaffected.

For instance, Toyota and Nissan's facilities in Thailand were not physically damaged by the floods, but both firms had to interrupt production because of problems in procurement parts from providers that had been directly affected by the floods(Nissan, 2011;Toyota, 2012).

According to an investigation of Japanese enterprises about the effect of the floods in Thailand, including enterprises in both non-manufacturing and manufacturing sectors, 78 per cent of all respondents were indirectly or directly affected as shown in Table 6.5. Amongst the affected enterprises, the electronics sector, trading sector, automotive sector and metal and steel sector accounted for 11 per cent, 16 per cent, 17per cent and 9 per cent, respectively (JCCB, 2012).Those directly affected, mainly manufacturers, placed in the flooded industrial estates outstripped those outside the estates. Indirect damage involved supply distractions (JETRO, 2012).

Table 6.5. The impact of the Thai 2011 Floods on Japanese enterprises (JCCB, 2012)

Sector	Type of industry	Number of enterprises with direct damage " Buildings and equipment %"	Number of enterprises with direct damage in the inundated industrial estates%	Number of enterprises with direct damage outside the inundated industrial estates%	Number of enterprises with indirect losses due to supply chain disruption %	Net affected (%)	Number of respondent companies
Manufacturing	Food processing	4 (29)	2 (14)	2 (14)	11(79)	3(21)	14
	Textiles	3 (33)	1(11)	2(22)	5(56)	2(22)	9
	Chemicals	1 (4)	1 (4)	0(0)	19(79)	4(17)	24
	Steel and other metal	2 (7)	1(3)	1(3)	24(83)	3(10)	29
	General machinery	5 (42)	5 (42)	0(0)	8(67)	4(33)	12
	Electronics	20 (56)	18(50)	3(8)	31(86)	2(6)	36
	Automotive	7 (13)	6(11)	1(2)	47(84)	8(14)	56
	Others	9 (24)	7(18)	2(5)	26(68)	7(18)	38
	Manufacturing Total	51 (23)	41(19)	11(5)	171(78)	33(15)	218
Non-Manufacturing	Trading companies	5 (11)	4(9)	1(2)	45(100)	9(20)	45
	Retail	3 (27)	3(27)	2(18)	8(73)	3(27)	11
	Finance	2 (13)	0(0)	2(13)	10(63)	5(31)	16
	Construction and civil engineering	5 (29)	3(18)	3(18)	8(47)	9(53)	17
	Transportation and communication	2 (9)	0(0)	2(9)	18(78)	5(22)	23
	Others	1 (4)	0(0)	1(4)	15(63)	12(50)	24
	Non-Manufacturing total	18 (13)	10(7)	11(8)	104(76)	43(32)	136
Total		69 (19)	51(14)	22(6)	275(78)	76(21)	354

The floods in Thailand triggered important spill-over effects on other countries through the worldwide supply chains. The examples are illustrated in the following subsection.

6.3.2.1 Electrical part manufacture:

Given the close economic connections between Thailand and Japan, Thailand's supply chain distraction and manufacturing losses affected Japan, where the manufacturing production index decreased by 2.4 per cent (CEIC, 2012). This drop was managed by the decrease in electrical part manufacture which contracted by 3.7 per cent from October 2011 to January 2012 as illustrated in Figure 6.5 .

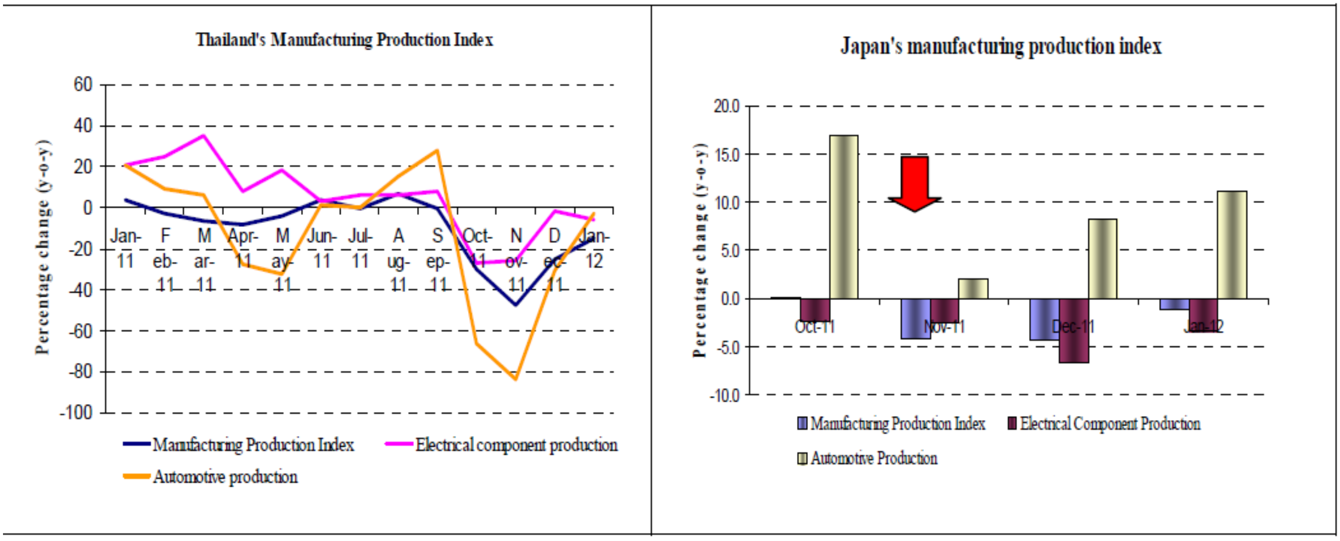


Figure 6.5. Disaster impact of the Southeast Asian floods on Japan's manufacturing sector (CEIC, 2012b)

6.3.2.2 Hard disk drives (HDDs)

As Thailand is the world's second main manufacturer of hard disk drives (HDDs), the drop in HDD production capability affected by the flood in Thailand caused an increase of the HDD value in the world market.

- The influence of the flooding in Thailand on the price of HDDs

Certain of the leading HDD manufacturers function in Thailand, including Hitachi, Toshiba, Seagate and Western Digital, and several of these manufacturers were affected by the floods. The international HDD industry had its worst downturn in three years and the world value of HDDs jumped dramatically.

According to the price histories data of Newegg Inc., a main online trader of computer software and hardware in North America, the values of HDDs produced by Western Digital and Seagate multiplied by three during the flood period. Furthermore to the direct slowdown of HDD manufacture in plants impacted by the flooding in Thailand, the HDD value climb was also affected by defensive procurements by inventory and consumers hoarding by wholesalers and resellers, who predicted the upward development of the value of HDDs. Figure 6.6 shows the prices of two HDD products.

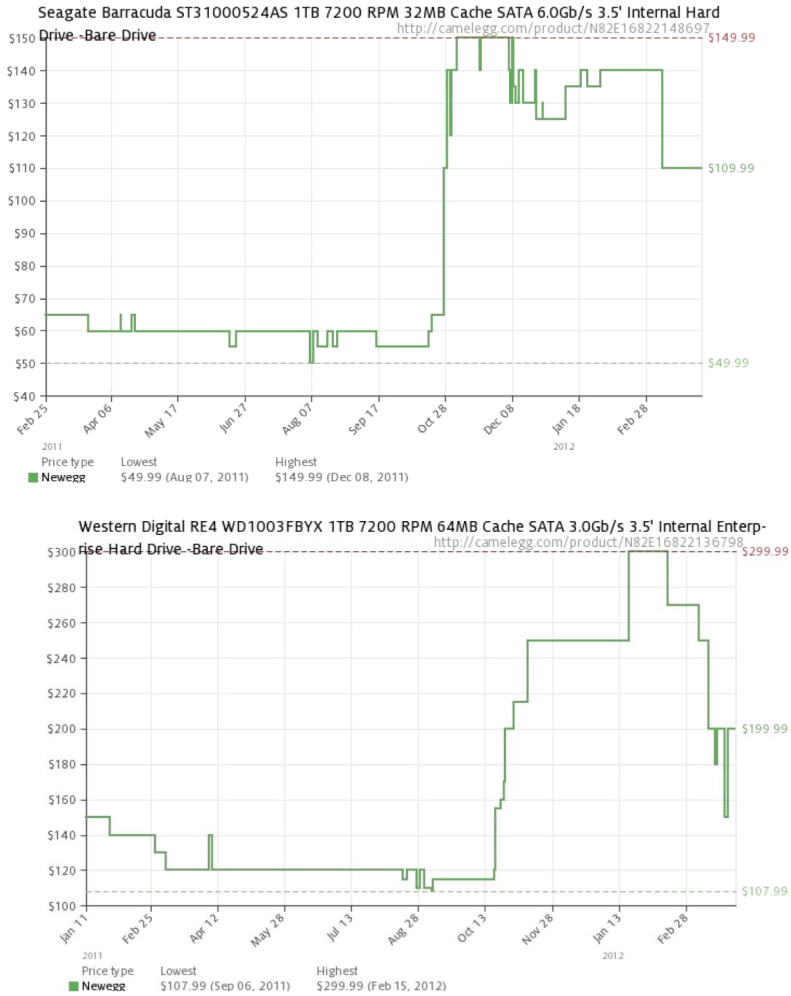


Figure 6.6. The price history of two HDD products(Price Tracker)

The severe influence of the flood on worldwide supply chains and the incompetent government management of flood rescue have higher investors' worries about the long-term feasibility of Thailand as an investment destination. According to an investigation of 50 international firms directly affected by the floods, 38 per cent of the companies stated that they would "scale back" in the future (JETRO, 2012). These businesses are worried about growths in manufacture costs because of greater insurance premiums, in addition to the cost of construction their own flood defences (Sathirathai, 2012). Even though Thailand functions as a significant linkage in the worldwide supply chains of some industries, more care should be paid to justifying the risks of likely future flooding and improving water resource controlling if the country is to remain an important investment destination.

6.4 Policy options to enhance disaster resilience

In light of the interdependency of trades because of the increase of worldwide supply chains, even comparatively minor supply disruptions triggered by a natural catastrophe can eventually have significances for all contributing firms in a supply chain. To address the hazards and build resilience to catastrophes, efforts from all individual objects and collaboration between the public and private sectors are needed.

The businesses elaborating in international supply chains must accept risk reduction policies to improve resilience. Two important policies are described below:

6.4.1 Find a balance between risk and efficiency

The tradeoffs between supply chain proficiency and catastrophe risk planning should be carefully measured. A proper balance between risk and efficiency is an important issue in supply chain management for improving disaster resilience. While obtaining from only one provider can decrease production costs, it can also make manufacturers vulnerable to disasters. On the other hand , having many providers in different places may increase transaction costs, but it decreases the risk of disruption by securing supply alternates. To reach a suitable balance between efficiency and risk, organizations should take hazard into account and conduct a prudent cost-benefit investigation and implement methods to improve disaster resilience. Such measures may take account of:

1) Raising production flexibility to cater to the volatile nature of the market,

2) Selecting suppliers on the basis of risk criteria rather than on pure cost minimization (Christopher, 2011),

3) Shortening the supply chain and increasing supply chain visibility,

4) Diversifying risks by using different distribution channels and suppliers,

5) Enhancing relationships with other supply chain partners (Catto-Smith, 2012).

To make the Decision easier, disaster resilience is increased by improving the way the supplies are selected and adding the probability of disaster happening in the country of the suppliers beside the quality, cost and lead time. A Decision Tree Analysis has been conducted to help the decision maker to deal with the uncertainty to improve the supply chain.

- Decision-Tree Modeling

Suppose we are a company searching to find raw material suppliers to their product, they are asked to deliver this item as fast as possible so that the company can enter the market earlier than the competitors. Now, let's assume that there are two different suppliers to the raw material but the possibility of disaster happening is different as shown in Figure 6.7. The first one is located in Tajikistan, where the possibility of disaster happening is 50 per cent, while the second supplier is in Turkmenistan where the possibility of disaster happening is 2 per cent. Which one should the company choose?

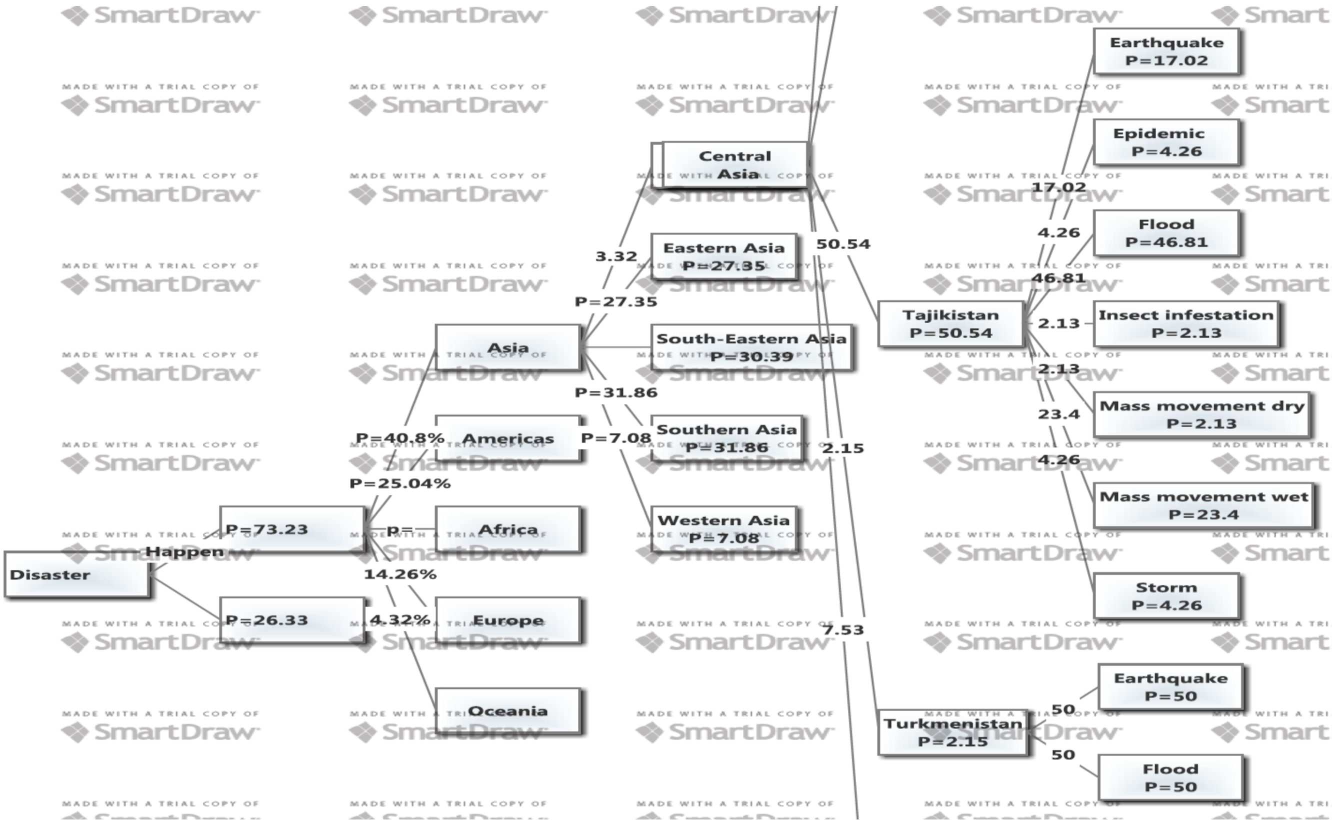


Figure 6.7. An sample case to define the "roll-up" idea. The decision nodes are represented by squares

The roll-up method discussed before can be used to select the best choice. In roll-up investigation, the probability rate at a chance node can be calculated by multiplying values beside the branches by its possibility and counting the results together.

Expected probability of disaster happening $=\sum_{i=1}^{N} \mathrm{Value}_n \times \mathrm{Probability}_n$

On the other hand, the probability assessment at the decision node is that of the top option (e.g. minimum probability of disaster happening, minimum time, etc.). Based on these rules, the probability of disaster happening in Tajikistan will be (0.5054*.0332*.408*0.73). While in Turkmenistan will be (0.0.0215*.0332*.408*0.73). By choosing the supplier with less probability of disaster occuring this will be improving disaster resilience which will develop the supply chain. See Appendix A .

6.4.2 Invest in long-term continuity

Businesses need to be aware that established capacities in disaster resilience and business stability are strong determinations of long-term effectiveness. Even during natural disasters the expansion in global supply chains has significantly increased the probability of production disruption from such disasters. As confirmed by the earthquake in Japan and the floods in Thailand, the effect of natural disasters may hamper a company by inhibiting production, financial losses and reduce market share in the long run. To emphasize their long-term affordability, organizations need to invest more in the long-term stability of the supply chain and implement hazard management measures. An inclusive assessment of a firm's vulnerability to catastrophes and the possible effect of a disaster on the supply chains that the firm is elaborate in can facilitate the establishment of hazard transfer, mitigation strategies and contingency financing. With the growing complexity of supply chains, it is also significant to emphasise on the management of critical sub-tier risks and share information with supply chain sources to improve network visibility

Disaster related supply chain disruptions are increasing across all geographic regions, critically threatening the manufacturing operations across many of world's production facilities. There is also a direct correlation between disaster-related economic losses and limited investment in risk management. Thus, there is a need to achieve resilience in networked global supply chain and explain why building resilience is essential and what type of strategies and actions are necessary by manufacturers, suppliers, distributors and governments to achieve resilience and minimize risks. The objective is to reduce the economic loss due to inventory shortage caused by the disaster situation. This is done by modifying the inventory management stock and safety stock by adding new concept called disaster safety stock. The outcomes will help manufacturers, suppliers and distributors of raw materials, parts and finished products in enriching their understanding of hazards accumulated from years of development without care to disasters and other vulnerabilities.

6.4.2.1 Order Quantity Model

6.4.2.1.1 Order Quantity Model with Safety Stock

A fixed order quantity system perpetually controls the inventory level and places a new order when stock reaches some level, R . In this model ,the risk of stock-out happens only during the lead time. As shown in Figure 6.8, an order is placed when the inventory point drops to below the reorder point, R . During the lead time L , a variety of demands is possible. The range of the demands is determined either from a study of historical demand data or from estimation if historical data are not accessible (Russell and Taylor, 2010).

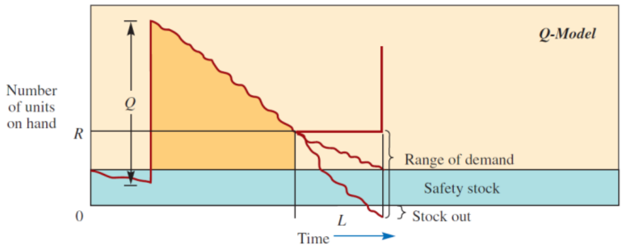


Figure 6.8: Order Quantity Model

The quantity of safety stock depends on the service level wanted, as discussed earlier. The quantity to be ordered, Q, is calculated in the normal way considering the holding cost, ordering cost, shortage cost, demand, and so forth. A fixed–order amount model can be used to calculate Q. The reorder point is then set to cover the predictable demand during the lead time plus a safety stock determined by the desired service level. Therefore, the important variance among a fixed–order quantity model where demand is identified and one where demand is undefined is in calculating the reorder point. The order quantity is the same in both cases. The uncertainty part is taken into account in the safety stock (Russell and Taylor, 2010).

The reorder point is

$$R = \bar{d}L + z\sigma_L \qquad (6.1)$$

R = Reorder point in units,
$\bar{d}$ = Average daily demand,
L = Lead time in days (time between placing an order and receiving the items),
z = Number of standard deviations for a specified service probability,
σ_L = Standard deviation of usage during lead time.

- **Modify Order Quantity Model**

Recent disasters have demonstrated how vulnerable the networked global supply chain is. Accordingly what was mentioned before the concept of Emergency Safety Stock (ESS) is necessary to be incorporated into the manufacturing sector with the disaster situation.

The main objective in this method is to pre-plan for disaster before it happens. If the company has special kind of inventory for disaster situation they will be ready for any kind of problem. The disaster will not stop the operations. Figure 6.9 summarizes the concept of Order Quantity Model from the start in figure part A to the end with the ESS concept.

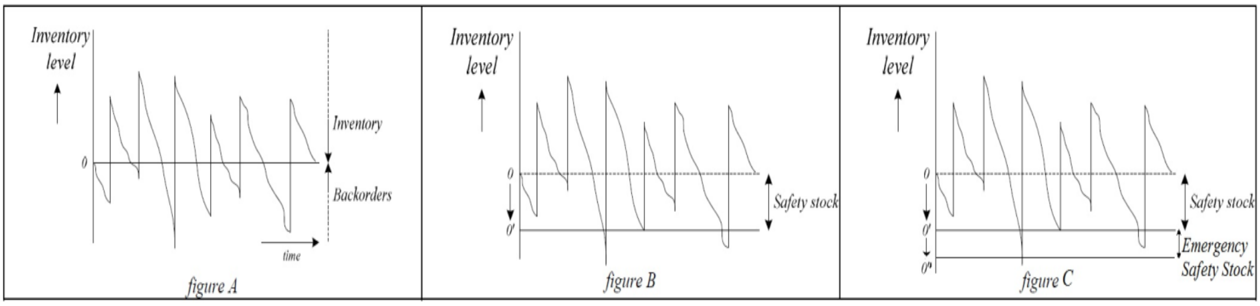


Figure 6.9: Order Quantity Model (A: without safety stock , B: with safety stock but without ESS, C: with safety stock and ESS)

- **How to calculate the ESS** :

These are three different ways proposed in this research to calculate the ESS. Each technique has different decision variable. So the company can choose what it prefers.

- The first method :

By adding the following value to the Order Quantity Model

$$\mathrm{ESS} = \bar{\mathrm{d}} \times \mathrm{P} \times \mathrm{N} \qquad (6.2)$$

ESS= Emergency Safety Stock,
$\bar{d}$ = Average daily demand,
P= Probability that the disaster will happen (see the probability Appendix 1),and
N= Number of days the disaster will continue.
The probability matrix has been found by using the disaster historical data for all the countries in the world. So the modified Order Quantity Model will be as in Equation (6.3)

$$R_{\mathrm{modify}} = \bar{\mathrm{d}}\mathrm{L} + z\sigma_{\mathrm{L}} + \bar{\mathrm{d}}\mathrm{PN} \qquad (6.3)$$

- The second method:

$$\mathrm{ESS} = \bar{\mathrm{d}} \times \mathrm{P} \times \mathrm{N}\,(1 + \mathrm{S})$$

S= the market share.
The market share for each country in the world has been calculated for different type of product, using data available from World Trade Organization (WTO) between 1980 and 2012. The following Table 6.6 shows sample of the market share for China, for the rest of the world it is shown in Appendix B)

China Agricultural products market share% $= \frac{\text{Total China Agricultural products tradig per year}}{\text{Total Agricultural products trade per yer}}$

$$= \frac{66175410327}{3926095984974} = 1.69\%$$

Table 6.6 : The market share for China for different type of product

Sum of cost	Country	Market share %
Agricultural products	China	1.69%
Automotive products	China	1.34%
Chemicals	China	2.33%
Clothing	China	16.54%
Electronic data processing and office equipment	China	17.61%
Food	China	1.72%
Fuels	China	0.43%
Fuels and mining products	China	0.63%
Integrated circuits and electronic components	China	7.52%
Iron and steel	China	4.69%
Machinery and transport equipment	China	6.95%
Manufactures	China	6.94%
Office and telecom equipment	China	13.82%
Pharmaceuticals	China	0.89%
Telecommunications equipment	China	15.14%
Textiles	China	14.75%

- The third method:

Statistical models have been found using the historical data, as shown in the sample

- **All**

```
The regression equation is
N = 18.6 + 0.711 M
M= Ln(Product code*Country code*P(Disaster)* #of Dis*Exports market shear for the
country%)


Predictor       Coef   SE Coef       T      P    VIF
Constant     18.5863    0.0760  244.72  0.000
M           0.711276  0.009396   75.70  0.000  1.000


S = 1.67842   R-Sq = 79.0%   R-Sq(adj) = 79.0%  R-Sq(pred) = 78.94%


Analysis of Variance

Source            DF     SS     MS        F      P
Regression         1  16142  16142  5729.94  0.000
Residual Error  1524   4293      3
Total           1525  20435
```

- **Agricultural products**

```
The regression equation is
N = 19.3 + 0.528 M
M= Ln(Country code*P(Disaster)* #of Dis*Exports market shear for the country%)


Predictor     Coef  SE Coef       T      P    VIF
Constant   19.3312   0.1746  110.71  0.000
M          0.52781  0.02281   23.14  0.000  1.000


S = 0.776359   R-Sq = 84.9%   R-Sq(adj) = 84.8%  R-Sq(pred) = 84.28%


Analysis of Variance

Source          DF      SS      MS       F      P
Regression       1  322.61  322.61  535.25  0.000
Residual Error  95   57.26    0.60
Total           96  379.87
```

- **Automotive products**

```
The regression equation is
n = 19.6 + 0.712 m
M= Ln(Country code*P(Disaster)* #of Dis*Exports market shear for the country%)

Predictor     Coef  SE Coef      T      P    VIF
Constant   19.5617   0.2596  75.36  0.000
m          0.71224  0.02405  29.61  0.000  1.000


S = 1.19895   R-Sq = 90.1%   R-Sq(adj) = 90.0%  R-Sq(pred) = 89.72%


Analysis of Variance

Source          DF      SS      MS       F      P
Regression       1  1260.7  1260.7  876.99  0.000
Residual Error  96   138.0     1.4
Total           97  1398.7
```

To see all the model(appendix 3)

Model discussion :

MINITAB Results and Discussions

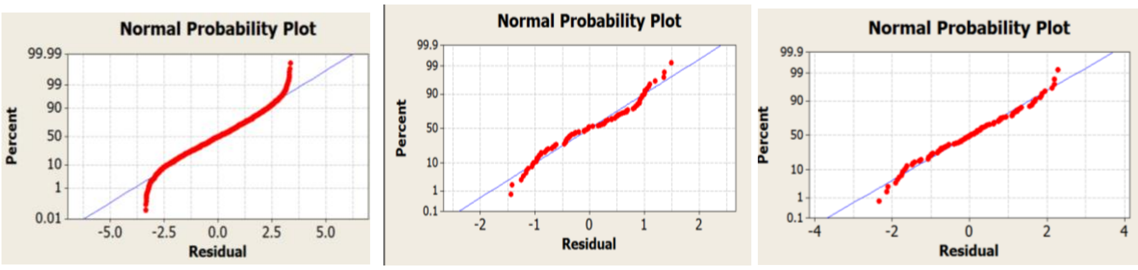
Regression Analysis Results

A multivariate regression analysis software (here Minitab is used) is applied to evaluate the coefficients (μ 's) related to each variable using the least square technique, and to test their impact. MINITAB also checks the importance of the multivariate linear regression model using the Analysis Of Variance (ANOVA).

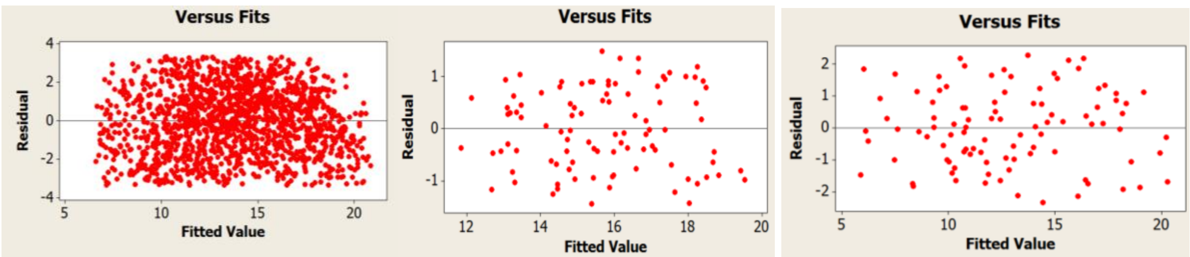
The above MINITAB result showed the multivariate linear regression analysis results for the ESS value for all type of trading items and individual item models. As can be shown, regression is significant and all the coefficients have their estimated sign. In order to agree whether or not a variable is important in a model, the p-value connected with each factor has been provided by the regression result in the above model. The variable that has a p-value lesser than 0.05 will be involved in the model, else, it will be removed, since its calculation will not develop the estimate of the response variable. All the p-value in the above three models are less than 0.05 ,so all the variables involved in the model are significant.

Model Adequacy Check:

In order to confirm the multivariate linear regression model, the acceptability of the model should be tested. First of all, the ANOVA tool used in the multivariate linear regression investigation to examine the significance and validity of the model is based on some rules, such as the residuals being normally distributed and having constant variance. A graphical investigation of the residuals can be used to check the validity of such expectations. As shown in Figure 6.10 (a) and (b), the analysis demonstrates acceptable results since the residuals are checked and assumption is satisfied and the aggregate normal distribution is around a straight line (the normality hypothesis is also satisfied). Secondly, bigger variation inflation factors (VIFs), generally greater than 5 (Montgomery and Runger, 2007), show that the connected regression coefficients are poorly assessed because of multicollinearity.



a(all items, Agricultural products, Automotive products)



b(all items, Agricultural products, Automotive products)

Figure 6.10. (a) Residual versus Fitted Values and (b) Normal Probability Plot, for the ESS (all items, Agricultural products, Automotive products)

Multicollinearity, which shows near-linear dependencies among the regression variables, can produce misleading results. As can be shown from above models, the variation inflation factor (VIF) for the factors is less than 10; this is a hint that multicollinearity does not occur in the model. Thirdly, the model appears to signify its data behaviour sufficiently well since the coefficient of determination (R^2), the adjusted R^2, and the predicted R^2 statistics are shown above 80% ; these are the most general measures of goodness-of-fit. Finally, all coefficients in the last model have the predictable signs, and their amounts seem to be reasonable. From the previous tests, one can conclude that the recommended model does not violate the core assumptions, and characterizes its data accurately. The complete equation for ESS for trading items becomes (see Appendix 3):

- General model :

$N = e^{18.6 + 0.711\,M}$

Where :

M= Ln(Product code*Country code*P(Disaster)* #of Dis*Exports market shear for the country%)

- **Agricultural products**

$N = e^{19.3 + 0.528\,M}$

Where :

M= Ln(Country code*P(Disaster)* #of Dis*Exports market shear for the country%)

- **Automotive products**

$N = e^{19.6 + 0.712\,M}$

Where :

M= Ln(Country code*P(Disaster)* #of Dis*Exports market shear for the country%)

- **Chemicals**

The regression equation is

N = 17.4 + 1.00 M

M= Ln(Country code*P(Disaster)* #of Dis*Exports market shear for the country%)

- **Clothing**

The regression equation is

N = 18.8 + 0.705 M

M= Ln(Country code*P(Disaster)* #of Dis*Exports market shear for the country%)

- **Electronic data processing and office equipment**

The regression equation is

N = 18.8 + 0.747 M

M= Ln(Country code*P(Disaster)* #of Dis*Exports market shear for the country%)

- **Food**

The regression equation is

N = 19.2 + 0.527 M

M= Ln(Country code*P(Disaster)* #of Dis*Exports market shear for the country%)

- **Fuels**

```
The regression equation is
N = 20.7 + 0.662 M
M= Ln(Country code*P(Disaster)* #of Dis*Exports market shear for the country%)
```

- **Fuels and mining products**

```
The regression equation is
N = 20.4 + 0.595 M
M= Ln(Country code*P(Disaster)* #of Dis*Exports market shear for the country%)
```

- **Integrated circuits and electronic components**

```
The regression equation is
N = 19.0 + 0.797 M
M= Ln(Country code*P(Disaster)* #of Dis*Exports market shear for the country%)
```

- **Iron and steel**

```
The regression equation is
N = 24.8 + 0.693 M
M= Ln(Country code*P(Disaster)* #of Dis*Exports market shear for the country%)
```

- **Machinery and transport equipment**

```
The regression equation is
N = 21.0 + 0.678 M
M= Ln(Country code*P(Disaster)* #of Dis*Exports market shear for the country%)
```

- **Manufactures**

```
The regression equation is
N = 21.7 + 0.654 M
M= Ln(Country code*P(Disaster)* #of Dis*Exports market shear for the country%)
```

- **Office and telecom equipment**

```
The regression equation is
N = 20.1 + 0.745 M
M= Ln(Country code*P(Disaster)* #of Dis*Exports market shear for the country%)
```

- **Pharmaceuticals**

```
The regression equation is
n = 18.9 + 0.745 m
M= Ln(Country code*P(Disaster)* #of Dis*Exports market shear for the country%)
```

- **Telecommunications equipment**

```
The regression equation is
n = 19.2 + 0.743 m
M= Ln(Country code*P(Disaster)* #of Dis*Exports market shear for the country%)
```

- **Textiles**

```
The regression equation is
n = 18.0 + 0.654 m
M= Ln(Country code*P(Disaster)* #of Dis*Exports market shear for the country%)
```

Model applied:

After the three ways have been found and explained above, the impact of these models in the global supply chain resilience has been found for each way. By using the data from WTO the trading value per US$ has been found for different items for each country in the world per year which are divided by 365 days to find the amount of trading per day. After that the disaster data from the Centre for Research on the Epidemiology of Disasters (CRED)'s EM-DAT worldwide database has been used to calculate how many disasters will happen in each country. In general when the disaster happens in any country, it will focus on the relief operation rather than trading, so the trading for this country will be zero in the disaster days. According to this assumption the cumulative value of trading for the disaster days has been calculated (sum of trading values losses due to disaster), as shown in the following Table 6.7.

Table 6.7 :The cumulative value of trading loss per year

Product type	Sum of Exports Trading loss /year
Agricultural products	4,538,207,595
Automotive products	3,549,461,954
Chemicals	5,398,034,398
Clothing	1,187,235,525
Electronic data processing and office equipment	1,679,620,754
Food	3,763,464,777
Fuels	9,213,525,339
Fuels and mining products	11,227,243,067
Integrated circuits and electronic components	1,519,718,967
Iron and steel	1,327,146,120
Machinery and transport equipment	16,496,370,270
Manufactures	32,496,577,757
Office and telecom equipment	5,157,121,097
Pharmaceuticals	1,389,712,980
Telecommunications equipment	1,957,768,613
Textiles	799,952,274

After the amount of trading losses per year for each type of product has been found, the distribution percentage of the global supply chain has been calculated if one of the three proposed ways has been applied. As can be seen in the distribution percentage Table 6.8, the global supply chain will be more flexible if ESS has been applied. The concept of ESS is not only applied by the suppliers, also it can be applied by the customer if there is only one supplier or supplier in disaster area.

Table 6.8: The distribution percentage of the global supply chain

Product type	dNP	dNP(1+share)	Model
Agricultural products	64.82%	62.17%	0.00%
Automotive products	66.19%	63.31%	0.00%
Chemicals	62.88%	59.86%	0.00%
Clothing	14.60%	0.00%	0.00%
Electronic data processing and office equipment	2.61%	0.00%	0.00%
Food	65.58%	63.06%	0.00%
Fuels	84.65%	84.11%	0.00%
Fuels and mining products	82.70%	82.07%	0.00%
Integrated circuits and electronic components	50.52%	44.62%	0.00%
Iron and steel	62.01%	58.75%	0.00%
Machinery and transport equipment	41.08%	33.31%	0.00%
Manufactures	42.80%	35.39%	0.00%
Office and telecom equipment	21.71%	3.24%	0.00%
Pharmaceuticals	74.25%	72.41%	17.70%
Telecommunications equipment	15.72%	0.00%	0.00%
Textiles	15.57%	0.00%	0.00%

6.5 Summary

In the age of globalization, companies in several industries are looking for the opportunity to globalize their supply chains to gain full benefit of the world resources and reduce manufacture costs. In this situation, supply chains are being extended internationally through offshore and outsourcing activities. The number of manufacture nodes and delivery links are continuously growing and fragmenting; however, businesses in the supply chain are becoming more interdependent. Simultaneously, supply chains are becoming more efficient through provider union and production mass to reach economies of scale.

Worldwide supply chains are vulnerable to the effects of natural catastrophes because the consolidation of manufacture bases, distribution channels and supplier networks concentrates hazards in certain places and reduces the probable alternatives in the market. Additionally, the substantial reliance on exact transport services for cross-border manufacture raises supply distractions in times of infrastructural catastrophe. Furthermore, supply chain policies that raise corporate efficiency may essentially deepen the negative effect of natural disasters. For SMEs elaborate in global supply chains, natural catastrophes pose particularly thoughtful risks.

As the two situation studies, the Japan earthquake and Thailand floods, presented, natural disasters can result into enormous national losses by damaging community infrastructure and production resources. Moreover, catastrophes can deteriorate firms' financial condition through growing sudden spending and hindering external financing. Moreover due to direct damages from the natural catastrophes, companies might be affected indirectly because of supply distractions, even when the disasters happen in different regions or countries. The indirect influences can tumble over to the worldwide supply chains, which may lead to price fluctuations and production losses in many businesses. Furthermore, the loss produced by natural disasters in selected countries, particularly in developing countries, may hamper their worldwide affordability and source concern among foreign stockholders.

Enterprises must reflect outside themselves if they are to decrease their vulnerability to supply chain disruption. The trade-offs between risk and efficiency in supply chain management should be carefully stable and further effort should be given to building catastrophe resilience to confirm long-term affordability. Companies in managing risks arising from natural catastrophes should be explored in areas such as choosing the suppliers and risk reduction policies. Selecting suppliers is one of the most important issue that the company faces to continue work in business. The decision tree analyses has been conducted to include the disaster risk factor in the calculation of choosing the company suppliers. If the company suppliers face any natural disaster the influence of disaster will affect the company by shortage in some type of raw material such as what happened to car industry which were affected by Japan disasters. Implementation of ESS concept will add more flexibility in the global supply chain, which makes the global supply chain work in normal situation if both the customer and suppliers improve their inventory control.

CHAPTER 7

Conclusions & Outlook

7.1 Conclusions :

In the previous chapters, several modelling strategies were investigated and solution methods were proposed to address the emergency logistics planning. Numerous tools were also used to predict the uncertain variables by using historical data from year 1901 to 2011. The contribution of this research can be summarized and concluded as follows:

- Global prediction tools such as time series analysis, regression modelling, and Neuro-fuzzy network were proposed to forecast the four parameters in an attempt to plan for emergency logistics: the aggregate number of people affected, economic losses, number of natural disasters, and the number of people killed. The best fit curve or probability distributions were also identified. Linear regression modelling was also used; however, the model was rejected due to low R^2 value of less than 85 per cent. Second country prediction tools such as logistic regression modelling and the decision tree analysis were also used. The forecasting models' efficiency was verified through comparison with actual historical data.
- In addition, the Ordinal Logistic Regression model has been identified by using MINITAB. This model is used to determine the forecast for the type of disaster. Because each type of disaster requires different relief material and equipment to be used in the rescue operation, the forecast leads to better coordination of search and rescue activities and efficient evacuation of injured people. Due to limitations of Ordinal Logistic Regression method, larger samples are needed compared to linear regression because maximum likelihood coefficients are large sample estimates. A minimum of 50 cases per predictor is recommended. Further, Decision Tree Model helps to find an approximate number of people to start relief operation. This information can be gathered to respond faster to the emergency situation. Subsequently, it can be modified to the actual data situation.
- Based on the forecast results of the proposed forecasting model, a simulation method was proposed to address uncertainties related to disaster occurrence, type of disaster, type of disaster in each country, number of injured and affected people and commodities demands in emergency logistics problems and to build an emergency supply chain model. As the current literature focussed on the simulation modelling of the evacuation process in the disaster situation only, building of the proposed emergency supply chain simulation model covers the gap in the literature. In addition, the proposed simulation model helped to study the impact of applying the JIT concept in the emergency situation. Moreover, the facility location problem which is one of the most important problems that can affect the relief operations was also addressed as an extension of the basic emergency logistics planning.

Overall health conditions of everyone in the affected area depend on the timely availability of commodities such as food shelter and medicine.

- The simulation model was validated using the actual historical data for different parameters. Implementation of the proposed solutions has also been taken into account. All the probability values of disaster occurrence, number of victims and the occurrence of each type of disaster are within the 95% confidence intervals. There is no big difference between the simulated estimates and the results from the probability of disaster occurrence, which help in reconfirming the validity of the simulation model with respect to these variables.
- In the simulation model development, three levels of warehouses were considered using the concept of just-in-time to improve the supply chain flexibility. This concept and the simulation model form a solution framework to better coordinate search and rescue activities and efficiently distribute the relief materials to injured and affected people. The final output from the simulation model was lead time which is most significant. The result was acceptable because the lead time did not exceed the golden 72 hours in search and rescue process. The proposed model is valid to improve the response time and the forecasts for the demand and location have good impact on the emergency relief supply chain .
- The critical success factors (CSF) which are prominent within normal supply chains are just as applicable to those in humanitarian aid distribution. A number of CSFs have been recognized as dominant to effective disaster reaction; while these have not always been spoken sufficiently in humanitarian aid environments. For instance, in disaster situations freight or transport rates are forced up the detriment of the aid presenters and the receivers of the aid. This clearly shows that extra sophisticated strategic planning may produce better control of the supply chain. The factors within which effective transport management can be directed therefore need to be carefully well-defined.
- Emergency supply chain work flow with CSFs has been proposed. The procedure is divided into two parts, the first one is protection and pre-planning and the second is response and support. The first part includes partnership between people and community within the policies and standards, also how to deal with data such as data verification and data storage. The other part is when the disaster happens. The implementation time to the emergency disaster plan is start time. The idea is the proposed flow that the plan will update continuously with the cooperation between three teams working together at the same time. The first team is NGO’s and government, the second team is volunteer technology group and the last team is the disaster victims.

- As a result of globalization of companies in several industries, supply chains are being extended globally through offshore outsourcing activities. The number of manufacturing nodes and delivery links are also continuously growing, fragmenting and becoming more interdependent. However, worldwide supply chains are vulnerable to the effects of natural catastrophes due to the consolidation of manufacturing bases, distribution channels and supplier networks concentrated hazards in certain places. Furthermore, supply chain policies that raise corporate efficiency may essentially deepen the negative effect of natural disasters. Findings from the Japan earthquake and Thailand floods in this study suggest that natural disasters can cause enormous national losses by damaging community infrastructure and production facilities. Moreover, catastrophes can deteriorate firms' financial condition through growing sudden spending, supply distractions even when the disasters happen in different regions or countries, and the indirect influences that can tumble over to the worldwide supply chains, resulting into price fluctuations and production losses. Enterprises must decrease their vulnerability to supply chain interruption and build catastrophe resilience to confirm long-term affordability. Companies in managing risks arising from natural catastrophes should explore in areas such as selecting the suppliers and risk reduction policies. The proposed decision tree model has been used to include the disaster risk factors in the selection of suppliers. If the suppliers face any natural disaster it will lead to shortage of raw material, parts and components such as what happened to car industry after tsunami in Japan. Implementation of ESS concept adds more flexibility to the global supply chain which works interruption-free like a normal supply chain.

7.2 Research limitations:

There are many different limitations in this study:

1. The assumptions that have been made, such as the relief material as one package that includes what the disaster victims need. Also, the severity of the disaster has been included by finding the average number of victims for each kind of disaster for each country in the world.
2. Linear regression modelling limitation is the R2 value is more than 85% .
3. There are a few limitations of Ordinal Logistic Regression method of forecasting. Larger samples are needed than for linear regression because maximum likelihood coefficients are large sample estimates. A minimum of 50 cases per predictor is recommended. Careful consideration is needed in interpretation when comparing multiple categories. Like any regression model, ordinal logistic regression has assumptions, which should be carefully scrutinized.
4. The fuzzy logic system has many limitations. (a) the type of membership function(MF), (b) the number of MF, and (c) the MF location.

5. The decision tree analysis has inherent limitations: (1)inadequacy in applying regression, (2) possibility of spurious relationships, (3) difficulty in representing functions such as parity or exponential size, (4) possibility of duplication with the same sub-tree on different paths, and (5) limited to one output per attribute, and inability to represent tests that refer to two or more different objects.
6. The data availability for some of the variables, for example, how long the disaster and the relief operations stay. Also, what are the relief materials required for the different type of disasters. Furthermore, how is the relief materials' demand change during the disaster.

7.3 Future Research Directions :

7.3.1 Model Extension and Simulation

The ARENA simulation model proposed in Chapter 4 is essentially addressing uncertainties in emergency logistics planning problems; however, due to its practical importance, this topic is worth further investigation on modelling aspects. Besides the uncertain parameters related to injured and affected people and commodities demands discussed in this thesis, there are several other practical factors and parameters that can be taken into consideration such as volume capacity or weight of transportation and required runway length. For instance, each aircraft has different capacity; Dash 7 has 5.12 MT weight capacity, 59 m3 volume capacity and 669 m runway length, while Dash 8 has 3.85 MT, 39 m3 and 821 m. Additionally, different requirement of relief materials when the type of disaster changes should be included in the model in future study. In the proposed model, the common relief material that the victims need when the disaster happens is included. In addition, the number of levels of warehouses can be increased from 3 to 4 levels by adding a subregional warehouse in the future study. This may improve the relief material distribution to disaster area.

7.3.2 Facility Location Problem

The probability of disaster occurrences has been used to find the coordinates of the facility location in this study. Besides this probability of disaster occurrence parameter, many different parameters can be used to determine the location of facility while using the center of gravity method such as accessibility, infrastructure availability in the area and risk opportunities to occur in this area. The accessibility to the area and infrastructure availability can be found by ranking it between 1 "bad accessibility" and 10 "good accessibility" for all the countries based on for example number of airports, number of ports, and so on. Subsequently, the risk opportunities to occur in a particular area can be determined by applying ABC analysis to historical data, "A" for high risk and "C" for low risk. Service failure may be another source of risk due to demolished hospitals and major supply centers, risk of no-usability of equipment. Finally, these results can be used to calculate a new weight factor as an input variable in the center of gravity method to locate a new facility. This consideration in future research can reduce the response time to disaster.

7.3.3 Prepare a camp layout

The proposed layout will include different variables according to UN recommendation. There is a recommended shelter space requirement per person. Moreover, a layout for the camp with capacity of, for example, 20000 people can be prepared. According to the UN, the camp should include many different facilities such as latrine, water tap, health centre, school, refuse drums and so on. The UN has also put constraint for the location of these facilities, for example latrine located not farther than 50 m from user housings and not closer than 6 m. Other examples include Tap stands placed not farther than 100 m from user rooms. The idea is to prepare a layout including all these variables and parameters to provide a good life level to the victims. In addition, this will improve the rescue operations.

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Appendix A

Decision-Tree Modeling.

.P(Disaster)	Continent	NO. of killed	No. of Victims	Damages	P(Hit by natural disasters)	Region	NO. of killed	No. of Victims	Damages	P(Hit by natural disasters)	Country	NO. of killed	No. of Victims	Damages	P(Hit by natural disasters)	Type of disaster	Average of no_killed	Average of No. of Victims	Average of total damages ('000 US$)	Hit by natural disasters	NO. of killed	No. of Victims	Damages	P(Hit by natural disasters)
73.23%	Africa	4.72%	2.90%	0.70%	15.58%	Eastern Africa	33.05%	68.78%	13.34%	40.82%	Burundi	2.64%	1.65%	0.00%	6.19%	Earthquake	3	120	0.0	1	0.5%	0.0%	0.0%	**3.7%**
																Epidemic	82	104887	0.0	7	92.6%	86.3%	0.0%	**25.9%**
																Flood	2	5122	0.0	13	3.5%	7.8%	0.0%	**48.1%**
																Storm	4	8228	0.0	6	3.4%	5.8%	0.0%	**22.2%**
											Comoros	0.07%	0.56%	0.00%	1.83%	Epidemic	7	749	0.0	2	82.4%	0.5%	0.0%	**25.0%**
																Flood	2	2500	0.0	1	11.8%	0.9%	0.0%	**12.5%**
																Storm	0	300	0.0	1	0.0%	0.1%	0.0%	**12.5%**
																Volcano	0	71050	0.0	4	5.9%	98.5%	0.0%	**50.0%**

Djibouti	1.08%	0.47%	0.12%	**1.61%**	**Epidemic**	19	886	0.0	3	22.5%	1.1%	0.0%	**42.9%**
					Flood	65	80000	706.3	3	77.5%	98.6%	100.0%	**42.9%**
					Storm	0	775	0.0	1	0.0%	0.3%	0.0%	**14.3%**
Eritrea	0.01%	0.04%	0.30%	**0.92%**	**Flood**	0	3507	0.0	2	0.0%	30.9%	0.0%	**50.0%**
					Insect infestation	0	0	0.0	1	0.0%	0.0%	0.0%	**25.0%**
					Storm	3	15675	5165.0	1	100.0%	69.1%	100.0%	**25.0%**
Ethiopia	10.17%	27.46%	0.95%	**11.70%**	**Drought**	0	12600000	0.0	1	0.0%	88.9%	0.0%	**2.0%**
					Epidemic	90	2879	0.0	6	22.7%	0.1%	0.0%	**11.8%**
					Flood	48	40857	423.7	38	75.5%	11.0%	100.0%	**74.5%**
					Insect infestation	0	0	0.0	1	0.0%	0.0%	0.0%	**2.0%**
					Mass movement dry	13	0	0.0	1	0.5%	0.0%	0.0%	**2.0%**
					Mass movement wet	13	97	0.0	2	1.1%	0.0%	0.0%	**3.9%**
					Volcano	5	2000	0.0	1	0.2%	0.0%	0.0%	**2.0%**
					Wildfire	0	5	0.0	1	0.0%	0.0%	0.0%	**2.0%**
Kenya	11.39%	21.38%	6.60%	**12.61%**	**Drought**	0	2700000	0.0	1	0.0%	24.5%	0.0%	**1.8%**
					Earthquake	1	0	50000.0	2	0.0%	0.0%	89.0%	**3.6%**
					Epidemic	117	401337	0.0	17	74.5%	61.8%	0.0%	**30.9%**
					Flood	20	48656	398.0	31	23.4%	13.7%	11.0%	**56.4%**

																Mass movement wet	14	7	0.0	4	2.1%	0.0%	0.0%	**7.3%**
											Madagascar	7.30%	10.98%	45.72%	**8.72%**	**Epidemic**	121	3055	0.0	1	7.0%	0.1%	0.0%	**2.6%**
																Flood	10	27197	30000.0	5	3.0%	2.4%	19.3 %	**13.2 %**
																Insect infestation	0	0	3500.0	1	0.0%	0.0%	0.4%	**2.6%**
																Storm	50	17831 8	20141.3	31	89.9 %	97.5 %	80.3 %	**81.6 %**
											Malawi	5.81%	2.84%	1.87%	**5.96%**	**Earthquake**	2	10368	0.0	2	0.3%	1.4%	0.0%	**7.7%**
																Epidemic	113	3257	0.0	7	57.8 %	1.6%	0.0%	**26.9 %**
																Flood	35	88918	1986.8	16	41.1 %	97.0 %	100. 0%	**61.5 %**
																Storm	11	8	0.0	1	0.8%	0.0%	0.0%	**3.8%**
											Mauritius	0.04%	0.02%	10.90%	**1.38%**	**Storm**	2	1975	30900.0	6	100. 0%	100. 0%	100. 0%	**100. 0%**
											Mozambique	8.71%	14.44%	5.20%	**7.80%**	**Drought**	5	17097 50	25000.0	2	0.4%	45.9 %	56.5 %	**5.9%**
																Earthquake	4	1476	0.0	1	0.2%	0.0%	0.0%	**2.9%**
																Epidemic	170	27950	0.0	9	74.5 %	3.4%	0.0%	**26.5 %**
																Flood	6	93546	0.0	7	2.1%	8.8%	0.0%	**20.6 %**
																Mass movement wet	87	2500	0.0	1	4.3%	0.0%	0.0%	**2.9%**
																Storm	25	24002 4	2965.4	13	16.0 %	41.9 %	43.5 %	**38.2 %**
																Wildfire	49	3023	0.0	1	2.4%	0.0%	0.0%	**2.9%**

Reunion	0.08%	0.01%	2.94%	**0.92%**	**Storm**	5	948	12500.0	4	100.0%	100.0%	100.0%	**100.0%**
Rwanda	1.82%	0.12%	0.00%	**4.59%**	**Earthquake**	41	1143	0.0	2	18.9%	3.6%	0.0%	**10.0%**
					Epidemic	25	614	0.0	7	41.4%	6.7%	0.0%	**35.0%**
					Flood	16	6184	1.1	8	29.2%	77.3%	100.0%	**40.0%**
					Mass movement wet	15	2646	0.0	3	10.5%	12.4%	0.0%	**15.0%**
Seychelles	0.03%	0.02%	1.86%	**0.69%**	**Earthquake**	3	4830	30000.0	1	37.5%	37.5%	94.6%	**33.3%**
					Flood	5	1237	1700.0	1	62.5%	9.6%	5.4%	**33.3%**
					Storm	0	6800	0.0	1	0.0%	52.8%	0.0%	**33.3%**
Somalia	18.27%	4.53%	5.88%	**8.72%**	**Drought**	0	200000	0.0	1	0.0%	8.5%	0.0%	**2.6%**
					Earthquake	298	105083	100000.0	1	6.9%	4.5%	100.0%	**2.6%**
					Epidemic	130	2397	0.0	11	33.2%	1.1%	0.0%	**28.9%**
					Flood	106	83694	0.0	24	59.1%	85.8%	0.0%	**63.2%**
					Storm	30	0	0.0	1	0.7%	0.0%	0.0%	**2.6%**
Tanzania Uni Rep	17.97%	8.47%	0.22%	**10.55%**	**Drought**	0	1900000	0.0	2	0.0%	86.9%	0.0%	**4.3%**
					Earthquake	3	1698	0.0	5	0.4%	0.2%	0.0%	**10.9%**
					Epidemic	282	3925	0.0	13	86.7%	1.2%	0.0%	**28.3%**
					Flood	24	23205	172.3	22	12.5%	11.7%	100.0%	**47.8%**

																Mass movement wet	13	150	0.0	1	0.3%	0.0%	0.0%	**2.2%**
																Storm	2	1553	0.0	2	0.1%	0.1%	0.0%	**4.3%**
																Wildfire	0	0	0.0	1	0.0%	0.0%	0.0%	**2.2%**
											Uganda	5.34%	0.89%	4.17%	**8.03%**	**Earthquake**	2	16667	23333.3	3	0.6%	10.9%	98.6%	**8.6%**
																Epidemic	45	8026	0.0	13	46.7%	22.7%	0.0%	**37.1%**
																Flood	18	23238	83.3	12	17.6%	60.7%	1.4%	**34.3%**
																Mass movement wet	140	5387	0.0	3	33.4%	3.5%	0.0%	**8.6%**
																Storm	6	2538	0.0	4	1.8%	2.2%	0.0%	**11.4%**
											Zambia	1.56%	5.01%	1.22%	**3.67%**	**Epidemic**	40	3558	0.0	8	86.6%	1.1%	0.0%	**50.0%**
																Flood	6	365273	2957.1	7	10.9%	98.9%	100.0%	**43.8%**
																Mass movement wet	9	150	0.0	1	2.5%	0.0%	0.0%	**6.3%**
											Zimbabwe	7.69%	1.08%	12.04%	**4.13%**	**Epidemic**	159	46322	0.0	11	96.7%	91.3%	0.0%	**61.1%**
																Flood	10	9764	40720.0	5	2.8%	8.7%	99.4%	**0.1%**
																Storm	4	0	600.0	2	0.4%	0.0%	0.6%	**0.0%**
						Middle Africa	**14.39%**	**4.32%**	**0.22%**	**13.95%**	**Angola**	3.42%	23.74%	36.02%	**#####**	**Epidemic**	14	103	0.0	2	7.7%	0.0%	0.0%	**9.1%**
																Flood	16	40511	526.3	19	88.6%	100.0%	100.0%	**86.4%**
																Mass movement wet	13	0	0.0	1	3.7%	0.0%	0.0%	**4.5%**
											Cameroon	23.15%	6.92%	6.12%	**14.77%**	**Drought**	0	186900	0.0	1	0.0%	83.3%	0.0%	**4.5%**
																Epidemic	226	1782	0.0	10	95.4	7.9%	0.0%	**45.5**

										%			**%**
					Flood	11	2074	0.0	8	3.7%	7.4%	0.0%	**36.4 %**
					Insect infestation	0	0	1700.0	1	0.0%	0.0%	100. 0%	**4.5%**
					Mass movement wet	20	100	0.0	1	0.8%	0.0%	0.0%	**4.5%**
					Volcano	0	3010	0.0	1	0.0%	1.3%	0.0%	**4.5%**
Central African Rep	5.21%	4.25%	0.00%	**13.42%**	**Epidemic**	102	743	0.0	5	95.7 %	2.7%	0.0%	**25.0 %**
					Flood	2	12586	0.0	10	2.8%	91.4 %	0.0%	**50.0 %**
					Storm	2	2434	0.0	3	1.3%	5.3%	0.0%	**15.0 %**
					Wildfire	1	418	0.0	2	0.2%	0.6%	0.0%	**10.0 %**
Chad	20.59%	30.07%	0.00%	**11.41%**	**Drought**	0	35600 0	0.0	1	0.0%	36.5 %	0.0%	**5.9%**
					Epidemic	502	4751	0.0	4	95.3 %	1.9%	0.0%	**23.5 %**
					Flood	8	54559	0.0	11	4.1%	61.5 %	0.0%	**64.7 %**
					Storm	14	145	0.0	1	0.7%	0.0%	0.0%	**5.9%**
Congo	2.68%	3.48%	0.21%	**7.38%**	**Earthquake**	6	1505	0.0	1	2.2%	1.3%	0.0%	**9.1%**
					Epidemic	65	182	0.0	4	94.5 %	0.6%	0.0%	**36.4 %**
					Flood	2	18417	9.8	6	3.3%	98.0 %	100. 0%	**54.5 %**
Gabon	####	####	####	**###**	**Epidemic**	20	0	0.0	1	100. 0%	0.0%	0.0%	**33.3 %**
					Storm	0	1283	0.0	2	0.0%	100. 0%	0.0%	**66.7 %**
o	77	47	64	**24**	**Earthquake**	10	8833	3500.0	2	0.4%	1.7%	43.8	**3.7%**

																%	
										Epidemic	150	20037	0.0	27	88.5 %	53.0 %	0.0%	**50.0 %**
										Flood	14	16298	0.0	15	4.4%	24.0 %	0.0%	**27.8 %**
										Mass movement wet	29	584	0.0	2	1.3%	0.1%	0.0%	**3.7%**
										Storm	10	25757	0.0	4	0.9%	10.1 %	0.0%	**7.4%**
										Volcano	100	55200	4500.0	2	4.4%	10.8 %	56.3 %	**3.7%**
										Wildfire	4	1448	0.0	2	0.2%	0.3%	0.0%	**3.7%**
Northern Africa	**14.87%**	**5.55%**	**71.27%**	**12.83%**	**Algeria**	37.74%	11.55%	71.96%	**35.77%**	Earthquake	275	26817	562325.4	9	61.9 %	50.2 %	77.4 %	**18.4 %**
										Epidemic	1	284	0.0	2	0.0%	0.1%	0.0%	**4.1%**
										Extreme temperature	40	0	0.0	1	1.0%	0.0%	0.0%	**2.0%**
										Flood	43	7222	44876.3	33	35.7 %	49.6 %	22.6 %	**67.3 %**
										Mass movement wet	15	696	0.0	1	0.4%	0.1%	0.0%	**2.0%**
										Storm	9	5	0.0	2	0.4%	0.0%	0.0%	**4.1%**
										Wildfire	22	0	0.0	1	0.6%	0.0%	0.0%	**2.0%**
					Egypt	14.00%	6.31%	14.76%	**14.60%**	Earthquake	187	30989	400000.0	3	37.9 %	35.4 %	89.4 %	**15.0 %**
										Extreme temperature	19	35	0.0	3	3.8%	0.0%	0.0%	**15.0 %**
										Flood	74	18722	15666.7	9	45.1 %	64.1 %	10.5 %	**45.0 %**
										Mass movement dry	66	499	0.0	2	8.9%	0.4%	0.0%	**10.0 %**
										Storm	21	47	333.3	3	4.2%	0.1%	0.1%	**15.0 %**

											Libyan Arab Jamah	0.00%	0.00%	0.46%	**0.73%**	**Flood**	0	0	42200.0	1	100.0%	100.0%	100.0%	**100.0%**
											Morocco	16.84%	5.92%	7.66%	**16.79%**	**Earthquake**	628	13465	400000.0	1	35.2%	5.5%	57.5%	**4.3%**
																Extreme temperature	0	0	809.0	1	0.0%	0.0%	0.1%	**4.3%**
																Flood	60	12258	15536.8	19	63.9%	94.5%	42.4%	**82.6%**
																Storm	8	0	25.0	2	0.8%	0.0%	0.0%	**8.7%**
											Sudan	30.64%	71.80%	2.49%	**28.47%**	**Drought**	0	600000	0.0	1	0.0%	20.1%	0.0%	**2.6%**
																Earthquake	3	15	0.0	1	0.1%	0.0%	0.0%	**2.6%**
																Epidemic	209	826	0.0	13	83.6%	0.4%	0.0%	**33.3%**
																Flood	20	113257	10771.4	21	13.2%	79.6%	100.0%	**53.8%**
																Storm	27	15	0.0	2	1.6%	0.0%	0.0%	**5.1%**
																Wildfire	47	0	0.0	1	1.4%	0.0%	0.0%	**2.6%**
											Tunisia	0.77%	4.42%	2.67%	**3.65%**	**Flood**	16	36802	48560.0	5	100.0%	100.0%	100.0%	**100.0%**
						Southern Africa	**1.54%**	**3.67%**	**12.15%**	**8.15%**	**Botswana**	2.10%	8.89%	0.32%	**4.60%**	**Drought**	0	100000	0.0	1	0.0%	40.9%	0.0%	**25.0%**
																Flood	12	72138	2500.0	2	100.0%	59.0%	100.0%	**50.0%**
																Storm	0	400	0.0	1	0.0%	0.2%	0.0%	**25.0%**

											Lesotho	7.04%	0.33%	0.00%	**9.20%**	**Epidemic**	28	1834	0.0	1	36.4%	20.2%	0.0%	**12.5%**
																Flood	16	1667	0.0	3	62.3%	55.0%	0.0%	**37.5%**
																Storm	0	563	0.0	4	1.3%	24.8%	0.0%	**50.0%**
											Namibia	27.17%	26.15%	0.55%	**#####**	**Drought**	0	163200	0.0	1	0.0%	22.7%	0.0%	**11.1%**
																Epidemic	74	6078	0.0	2	49.8%	1.7%	0.0%	**22.2%**
																Flood	25	90683	1415.0	6	50.2%	75.6%	100.0%	**66.7%**
											South Africa	57.73%	19.03%	99.13%	**67.82%**	**Earthquake**	9	37	6666.7	3	4.3%	0.0%	1.3%	**5.1%**
																Epidemic	21	3338	0.0	4	13.5%	2.5%	0.0%	**6.8%**
																Extreme temperature	26	0	0.0	2	8.2%	0.0%	0.0%	**3.4%**
																Flood	9	17584	21653.5	21	28.8%	70.5%	29.6%	**35.6%**
																Mass movement wet	34	0	0.0	1	5.4%	0.0%	0.0%	**1.7%**
																Storm	6	7031	32739.0	19	19.5%	25.5%	40.5%	**32.2%**
																Wildfire	14	820	48888.9	9	20.3%	1.4%	28.6%	**15.3%**
											Swaziland	5.95%	45.60%	0.00%	**8.05%**	**Drought**	0	970000	0.0	1	0.0%	77.3%	0.0%	**14.3%**
																Epidemic	31	1839	0.0	2	95.4%	0.3%	0.0%	**28.6%**
																Flood	0	272000	50.0	1	0.0%	21.7%	100.0%	**14.3%**
																Storm	1	3843	0.0	2	1.5%	0.6%	0.0%	**28.6%**
																Wildfire	2	1500	0.0	1	3.1%	0.1%	0.0%	**14.3**

																		%
Western Africa	36.15%	17.68%	3.02%	24.25%	Benin	####	####	####	###	**Epidemic**	52	1024	0.0	12	93.4%	1.4%	0.0%	**60.0%**
										Flood	6	111804	414.4	8	6.6%	98.6%	100.0%	**40.0%**
					Burkina Faso	####	####	####	###	**Epidemic**	587	4761	0.0	4	98.4%	7.7%	0.0%	**50.0%**
										Flood	9	57265	37500.0	4	1.6%	92.3%	100.0%	**50.0%**
					Cape Verde Is	0.96%	0.09%	0.00%	1.16%	**Drought**	0	0	0.0	1	0.0%	0.0%	0.0%	**33.3%**
										Epidemic	245	12344	0.0	1	98.8%	100.0%	0.0%	**33.3%**
										Flood	3	0	0.0	1	1.2%	0.0%	0.0%	**33.3%**
					Cote d'Ivoire	0.65%	0.10%	0.00%	3.09%	**Epidemic**	33	128	0.0	3	58.9%	3.0%	0.0%	**37.5%**
										Flood	11	613	0.0	4	25.0%	19.1%	0.0%	**50.0%**
										Mass movement wet	27	10006	0.0	1	16.1%	77.9%	0.0%	**12.5%**
					Gambia The	0.70%	0.54%	0.00%	3.86%	**Epidemic**	120	793	0.0	1	66.7%	1.1%	0.0%	**10.0%**
										Flood	11	10863	0.0	5	30.6%	75.5%	0.0%	**50.0%**
										Storm	1	4202	0.0	4	2.8%	23.4%	0.0%	**40.0%**
					Ghana	####	####	####	###	**Epidemic**	18	555	0.0	7	27.6%	0.1%	0.0%	**38.9%**
										Flood	29	311992	3045.5	11	72.4%	99.9%	100.0%	**61.1%**
					Guinea	1.54%	0.91%	0.00%	4.63%	**Drought**	12	0	0.0	1	3.0%	0.0%	0.0%	**8.3%**
										Epidemic	93	6072	0.0	4	93.4%	20.2%	0.0%	**33.3%**

																Flood	2	19058	0.0	5	2.5%	79.2%	0.0%	**41.7%**
																Storm	4	0	0.0	1	1.0%	0.0%	0.0%	**8.3%**
																Wildfire	0	777	0.0	1	0.0%	0.6%	0.0%	**8.3%**
											Guinea Bissau	7.55%	1.22%	0.00%	**2.70%**	**Drought**	0	100000	0.0	1	0.0%	61.7%	0.0%	**14.3%**
																Epidemic	646	19299	0.0	3	99.7%	35.7%	0.0%	**42.9%**
																Flood	3	1000	0.0	1	0.2%	0.6%	0.0%	**14.3%**
																Storm	0	1722	0.0	1	0.0%	1.1%	0.0%	**14.3%**
																Wildfire	3	1500	0.0	1	0.2%	0.9%	0.0%	**14.3%**
											Liberia	0.58%	7.87%	12.19%	**4.25%**	**Epidemic**	27	157	0.0	5	91.9%	0.1%	0.0%	**45.5%**
																Extreme temperature	0	1000000	47000.0	1	0.0%	95.8%	100.0%	**9.1%**
																Flood	4	12495	0.0	3	8.1%	3.6%	0.0%	**27.3%**
																Storm	0	2750	0.0	2	0.0%	0.5%	0.0%	**18.2%**
											Mali	####	####	####	**###**	**Epidemic**	33	282	0.0	1	50.8%	0.2%	0.0%	**7.7%**
																Flood	3	10378	0.0	12	49.2%	99.8%	0.0%	**92.3%**
											Mauritania	0.40%	4.56%	0.00%	**6.56%**	**Drought**	0	446507	0.0	1	0.0%	73.8%	0.0%	**5.9%**
																Epidemic	26	172	0.0	2	51.0%	0.1%	0.0%	**11.8%**
																Flood	4	13157	0.0	12	44.1%	26.1%	0.0%	**70.6%**
																Storm	3	239	0.0	2	4.9%	0.1%	0.0%	**11.8%**

Niger	26.08%	17.47%	0.00%	**9.27%**	**Drought**	0	1630000	0.0	1	0.0%	70.3%	0.0%	**4.2%**
					Epidemic	600	18362	0.0	11	98.4%	8.7%	0.0%	**45.8%**
					Flood	9	44007	0.0	11	1.6%	20.9%	0.0%	**45.8%**
					Storm	4	1253	0.0	1	0.1%	0.1%	0.0%	**4.2%**
Nigeria	42.81%	20.13%	28.74%	**26.64%**	**Epidemic**	345	1598	0.0	29	90.9%	1.7%	0.0%	**42.0%**
					Extreme temperature	39	0	0.0	2	0.7%	0.0%	0.0%	**2.9%**
					Flood	24	79474	3359.2	33	7.1%	98.2%	100.0%	**47.8%**
					Mass movement wet	16	150	0.0	2	0.3%	0.0%	0.0%	**2.9%**
					Storm	37	337	0.0	3	1.0%	0.0%	0.0%	**4.3%**
Senegal	0.93%	7.75%	10.63%	**5.79%**	**Epidemic**	7	121	0.0	1	2.9%	0.0%	0.0%	**6.7%**
					Flood	4	84637	3725.4	11	18.3%	90.6%	100.0%	**73.3%**
					Storm	63	32284	0.0	3	78.8%	9.4%	0.0%	**20.0%**
Sierra Leone	1.71%	1.67%	0.00%	**5.41%**	**Epidemic**	32	609	0.0	8	58.0%	2.2%	0.0%	**57.1%**
					Flood	39	54118	0.0	4	35.4%	97.8%	0.0%	**28.6%**
					Mass movement wet	16	5	0.0	1	3.6%	0.0%	0.0%	**7.1%**
					Storm	13	3	0.0	1	2.9%	0.0%	0.0%	**7.1%**
St Helena	0.00%	0.00%	0.00%	**0.39%**	**Storm**	0	300	0.0	1	100.0%	100.0%	100.0%	**100.0%**
Togo	###	###	###	**#**	**Epidemic**	142	1433	0.0	4	98.4	2.0%	0.0%	**44.4**

																			%			**%**
															Flood	2	55344	0.0	5	1.6%	98.0 %	0.0%	**55.6 %**
	Americas	**21.51%**	**3.54%**	**36.26%**	**25.04%**	**Caribbean**	**71.66%**	**22.83%**	**5.60%**	**15.78%**	**Anguilla**	0.00%	0.00%	0.00%	**0.37%**	**Storm**	0	150	50.0	1	100. 0%	100. 0%	100. 0%	**100. 0%**
											Antigua and Barbuda	0.00%	0.20%	1.25%	**2.58%**	**Storm**	1	6069	66085.7	7	100. 0%	100. 0%	100. 0%	**100. 0%**
											Bahamas	0.01%	0.15%	6.98%	**4.80%**	**Storm**	1	2477	199261. 5	13	100. 0%	100. 0%	100. 0%	**100. 0%**
											Barbados	####	####	####	**###**	**Earthquake**	0	1	0.0	1	0.0%	0.0%	0.0%	**20.0 %**
																Storm	0	1345	1300.0	4	100. 0%	100. 0%	100. 0%	**80.0 %**
											Cayman Islands	0.00%	0.00%	9.42%	**2.58%**	**Storm**	0	43	499511. 4	7	100. 0%	100. 0%	100. 0%	**100. 0%**
											Cuba	0.06%	55.39%	29.03%	**14.76%**	**Drought**	0	0	0.0	1	0.0%	0.0%	0.0%	**2.5%**
																Earthquake	0	5869	0.0	1	0.0%	0.1%	0.0%	**2.5%**
																Epidemic	0	49358	0.0	1	0.0%	0.4%	0.0%	**2.5%**
																Flood	5	52330	9506.0	15	53.9 %	6.8%	1.3%	**37.5 %**

					Storm	3	512505	506427.0	21	46.1%	92.8%	98.7%	**52.5%**
					Wildfire	0	0	0.0	1	0.0%	0.0%	0.0%	**2.5%**
Dominica	0.00%	0.07%	0.58%	**2.58%**	Earthquake	0	100	0.0	1	0.0%	0.7%	0.0%	**14.3%**
					Storm	1	2277	35833.3	6	100.0%	99.3%	100.0%	**85.7%**
Dominican Rep	0.61%	6.77%	6.92%	**14.76%**	Earthquake	3	2015	0.0	1	0.2%	0.1%	0.0%	**2.5%**
					Epidemic	10	368	0.0	4	2.8%	0.1%	0.0%	**10.0%**
					Flood	52	11284	6508.2	15	54.6%	11.9%	3.8%	**37.5%**
					Storm	32	65506	130063.7	19	42.4%	87.8%	96.2%	**47.5%**
					Wildfire	0	0	0.0	1	0.0%	0.0%	0.0%	**2.5%**
Grenada	0.02%	0.30%	2.41%	**1.48%**	Storm	10	15715	223625.0	4	100.0%	100.0%	100.0%	**100.0%**
Guadeloupe	0.00%	0.01%	0.96%	**2.21%**	Earthquake	1	153	0.0	1	20.0%	14.5%	0.0%	**16.7%**
					Storm	1	180	71000.0	5	80.0%	85.5%	100.0%	**83.3%**
Haiti	99.20%	31.09%	22.45%	**19.93%**	Earthquake	222570	3700000	8000000.0	1	96.5%	56.8%	96.0%	**1.9%**
					Flood	112	15365	37.0	27	1.3%	6.4%	0.0%	**50.0%**
					Storm	195	92199	12754.6	26	2.2%	36.8%	4.0%	**48.1%**
Jamaica	0.04%	4.72%	4.22%	**7.38%**	Epidemic	0	300	0.0	1	0.0%	0.0%	0.0%	**5.0%**
					Flood	9	146428	15250.0	4	34.7%	59.2%	3.9%	**20.0%**
					Storm	4	26848	100414.	15	65.3	40.7	96.1	**75.0**

																			3		%	%	%	**%**
											Martinique	0.01%	0.02%	1.24%	**2.95%**	**Earthquake**	1	100	0.0	1	7.7%	1.9%	0.0%	**12.5 %**
																Storm	2	731	65715.7	7	92.3 %	98.1 %	100. 0%	**87.5 %**
											Montserrat	0.01%	0.04%	0.08%	**1.48%**	**Storm**	0	0	10000.0	2	0.0%	0.0%	71.4 %	**50.0 %**
																Volcano	16	4000	4000.0	2	100. 0%	100. 0%	28.6 %	**50.0 %**
											Netherlands Antilles	0.00%	0.19%	2.69%	**0.37%**	**Storm**	2	40000	100000 0.0	1	100. 0%	100. 0%	100. 0%	**100. 0%**
											Puerto Rico	0.02%	0.83%	5.11%	**5.17%**	**Flood**	6	3121	86500.0	4	47.8 %	7.2%	18.2 %	**28.6 %**
																Storm	2	16119	155000. 0	10	52.2 %	92.8 %	81.8 %	**71.4 %**
											St Kitts and Nevis	0.00%	0.06%	1.72%	**1.48%**	**Storm**	1	3245	159600. 0	4	100. 0%	100. 0%	100. 0%	**100. 0%**
											St Lucia	0.01%	0.02%	0.11%	**2.95%**	**Earthquake**	0	0	0.0	1	0.0%	0.0%	0.0%	**12.5 %**
																Flood	0	2000	0.0	1	0.0%	48.5 %	0.0%	**12.5 %**
																Mass	0	175	0.0	1	0.0%	4.2%	0.0%	**12.5**

					movement wet								%
					Storm	3	390	8200.0	5	100.0%	47.3%	100.0%	**62.5%**
and The	0.00%	0.04%	0.11%	**2.58%**	**Flood**	2	238	0.0	2	42.9%	5.8%	0.0%	**28.6%**
					Storm	1	1547	8200.0	5	57.1%	94.2%	100.0%	**71.4%**
Trinidad and Tobago	0.00%	0.02%	0.07%	**3.32%**	**Earthquake**	0	17	25000.0	1	0.0%	0.5%	95.7%	**11.1%**
					Flood	3	105	35.0	2	62.5%	6.6%	0.3%	**22.2%**
					Mass movement wet	2	1200	0.0	1	25.0%	37.7%	0.0%	**11.1%**
					Storm	0	390	264.3	4	12.5%	48.9%	4.0%	**44.4%**
					Volcano	0	200	0.0	1	0.0%	6.3%	0.0%	**11.1%**
Turks and Caicos Is	0.00%	0.01%	1.35%	**1.85%**	**Storm**	1	340	100000.0	5	100.0%	100.0%	100.0%	**100.0%**
Virgin Is (UK)	0.00%	0.00%	0.03%	**0.74%**	**Storm**	0	2	6000.0	2	100.0%	100.0%	100.0%	**100.0%**

											Virgin Is (US)	0.00%	0.05%	3.28%	**1.85%**	**Storm**	2	2000	243200.0	5	100.0%	100.0%	100.0%	**100.0%**
						Central America	9.10%	24.06%	6.08%	23.41%	Belize	0.22%	0.97%	1.38%	**3.23%**	**Extreme temperature**	0	0	2250.0	1	0.0%	0.0%	0.4%	**7.7%**
																Flood	0	13533	4132.3	3	1.6%	19.0%	2.2%	**23.1%**
																Storm	7	19174	60261.9	9	98.4%	81.0%	97.4%	**69.2%**
											Costa Rica	0.91%	7.01%	2.48%	**10.45%**	**Earthquake**	10	17161	35500.0	9	34.3%	10.0%	32.0%	**21.4%**
																Epidemic	0	4786	0.0	1	0.0%	0.3%	0.0%	**2.4%**
																Flood	5	29443	18000.0	20	38.1%	38.1%	36.1%	**47.6%**
																Mass movement wet	7	200	0.0	1	2.6%	0.0%	0.0%	**2.4%**
																Storm	8	99605	39798.8	8	25.0%	51.5%	31.9%	**19.0%**
																Volcano	0	225	0.0	2	0.0%	0.0%	0.0%	**4.8%**
																Wildfire	0	1200	0.0	1	0.0%	0.1%	0.0%	**2.4%**
											El Salvador	8.89%	8.89%	8.82%	**8.71%**	**Earthquake**	290	401943	462125.0	4	44.2%	81.9%	52.0%	**11.4%**
																Epidemic	81	11192	0.0	6	18.6%	3.4%	0.0%	**17.1%**
																Flood	9	2026	136.4	11	3.8%	1.1%	0.0%	**31.4%**
																Mass movement wet	22	0	0.0	1	0.8%	0.0%	0.0%	**2.9%**
																Storm	71	21963	141900.8	12	32.5%	13.4%	47.9%	**34.3%**
																Volcano	2	2000	0.0	1	0.1%	0.1%	0.0%	**2.9%**

Guatemala	10.97%	5.77%	7.17%	**12.94%**	**Earthquake**	6	6181	12.5	4	0.8%	1.9%	0.0%	**7.7%**
					Epidemic	101	5598	0.0	6	18.6 %	2.6%	0.0%	**11.5 %**
					Extreme temperature	0	1850	0.0	1	0.0%	0.1%	0.0%	**1.9%**
					Flood	10	11095	71.4	14	4.4%	12.2 %	0.0%	**26.9 %**
					Mass movement dry	30	1514	0.0	2	1.8%	0.2%	0.0%	**3.8%**
					Mass movement wet	38	6742	62500.0	8	9.5%	4.2%	17.3 %	**15.4 %**
					Storm	191	90273	217000.0	11	64.9 %	77.9 %	82.7 %	**21.2 %**
					Volcano	0	1491	0.0	6	0.0%	0.7%	0.0%	**11.5 %**
Honduras	52.46%	16.18%	11.15%	**9.45%**	**Earthquake**	4	26010	50000.0	2	0.0%	1.5%	2.2%	**5.3%**
					Epidemic	3	8539	0.0	2	0.0%	0.5%	0.0%	**5.3%**
					Flood	38	57865	18940.0	20	5.0%	32.4 %	8.4%	**52.6 %**
					Storm	1132	180491	308629.2	13	95.0 %	65.7 %	89.3 %	**34.2 %**
					Wildfire	0	0	0.0	1	0.0%	0.0%	0.0%	**2.6%**
Mexico	11.97%	50.58%	66.36%	**35.57%**	**Drought**	0	0	100000.0	1	0.0%	0.0%	0.4%	**0.7%**
					Earthquake	11	32772	129153.8	13	4.1%	3.8%	6.3%	**9.1%**
					Epidemic	34	5763	0.0	2	1.9%	0.1%	0.0%	**1.4%**
					Extreme temperature	94	12364	52909.1	11	29.3 %	1.2%	2.2%	**7.7%**
					Flood	27	96426	96505.1	39	30.3 %	33.7 %	14.1 %	**27.3 %**
					Mass movement wet	18	36	0.0	9	4.6%	0.0%	0.0%	**6.3%**

														Storm	17	110063	337821.5	61	29.3%	60.1%	77.1%	**42.7%**
														Volcano	3	16915	0.0	7	0.6%	1.1%	0.0%	**4.9%**
											Nicaragua	13.77%	9.78%	2.55%	**11.69%**	Earthquake	47	3474	6250.0	4	4.6%	0.6%	2.4%	**8.5%**
																Epidemic	6	2505	0.0	7	1.1%	0.8%	0.0%	**14.9%**
																Flood	10	41376	45.8	12	3.1%	23.0%	0.1%	**25.5%**
																Mass movement wet	29	5769	0.0	1	0.7%	0.3%	0.0%	**2.1%**
																Storm	217	76011	58870.6	17	90.6%	59.8%	97.4%	**36.2%**
																Volcano	0	79443	180.5	4	0.0%	14.7%	0.1%	**8.5%**
																Wildfire	0	8000	0.0	2	0.0%	0.7%	0.0%	**4.3%**
											Panama	0.82%	0.82%	0.09%	**7.96%**	Earthquake	8	5378	0.0	4	13.2%	11.8%	0.0%	**12.5%**
																Epidemic	25	1089	0.0	4	41.6%	2.4%	0.0%	**12.5%**
																Flood	4	6733	1172.7	22	39.1%	81.6%	72.0%	**68.8%**
																Storm	8	3775	5025.0	2	6.2%	4.2%	28.0%	**6.3%**
							Northern America	**2.60%**	**28.38%**	**81.08%**	**33.55%**	**Bermuda**	0.05%	0.00%	0.06%	**0.17%**	Storm	4	0	300000.0	1	100.0%	100.0%	100.0%	**100.0%**
												Canada	1.69%	0.40%	1.11%	**10.24%**	Epidemic	12	190	0.0	3	25.2%	0.5%	0.0%	**5.1%**
																Flood	1	2749	63475.0	24	23.8%	62.9%	25.5%	**40.7%**
																Storm	3	404	124372.7	22	50.3%	8.5%	45.8%	**37.3%**
																Wildfire	0	2940	170950.	10	0.7%	28.0	28.6	**16.9**

																		0			%	%	**%**
											United States	98.26%	99.60%	98.83%	**89.58%**	**Earthquake**	5	4191	2182886.7	15	0.8%	0.2%	6.2%	**2.9%**
																Epidemic	34	134384	0.0	3	1.2%	1.6%	0.0%	**0.6%**
																Extreme temperature	90	2	133750.0	16	17.3%	0.0%	0.4%	**3.1%**
																Flood	6	111365	316146.1	107	7.5%	45.9%	6.4%	**20.7%**
																Mass movement wet	8	70	0.0	2	0.2%	0.0%	0.0%	**0.4%**
																Storm	19	40036	1406868.9	318	71.7%	49.1%	84.2%	**61.6%**
																Volcano	0	0	0.0	1	0.0%	0.0%	0.0%	**0.2%**
																Wildfire	2	15182	280688.9	54	1.3%	3.2%	2.9%	**10.5%**
						South America	**16.63%**	**24.74%**	**7.25%**	**27.26%**	**Argentina**	0.64%	2.15%	5.74%	**10.26%**	**Earthquake**	0	727	0.0	1	0.0%	0.1%	0.0%	**2.1%**
																Epidemic	67	3883	0.0	1	19.5%	0.8%	0.0%	**2.1%**
																Extreme temperature	7	7125	0.0	4	8.5%	5.9%	0.0%	**8.3%**
																Flood	6	14938	116530.9	23	38.8%	70.5%	97.1%	**47.9%**
																Mass movement wet	4	20000	15000.0	1	1.2%	4.1%	0.5%	**2.1%**
																Storm	7	2478	5909.1	11	22.7%	5.6%	2.4%	**22.9%**
																Volcano	0	21067	0.0	3	0.0%	13.0%	0.0%	**6.3%**
																Wildfire	8	0	0.0	4	9.3%	0.0%	0.0%	**8.3%**
											Bolivia	1.61%	3.49%	1.39%	**5.77%**	**Earthquake**	50	9025	0.0	2	11.5%	2.3%	0.0%	**7.4%**
																Epidemic	168	9191	0.0	2	38.6	2.3%	0.0%	**7.4%**

																					%			
																Extreme temperature	8	12641	0.0	2	1.7%	3.2%	0.0%	**7.4%**
																Flood	16	45641	22500.0	12	22.7%	69.1%	40.3%	**44.4%**
																Mass movement wet	36	28437	80000.0	6	25.1%	21.5%	59.7%	**22.2%**
																Storm	0	6655	0.0	1	0.0%	0.8%	0.0%	**3.7%**
																Wildfire	2	3150	0.0	2	0.3%	0.8%	0.0%	**7.4%**
											Brazil	5.75%	24.17%	9.69%	**19.87%**	**Drought**	0	0	0.0	1	0.0%	0.0%	0.0%	**1.1%**
																Earthquake	1	286	0.0	1	0.0%	0.0%	0.0%	**1.1%**
																Epidemic	40	73677	0.0	5	6.4%	6.7%	0.0%	**5.4%**
																Extreme temperature	4	0	237500.0	2	0.2%	0.0%	10.2%	**2.2%**
																Flood	39	81099	61308.0	59	75.0%	87.2%	77.7%	**63.4%**
																Insect infestation	0	2000	0.0	1	0.0%	0.0%	0.0%	**1.1%**
																Mass movement wet	42	12265	7166.7	13	17.4%	2.9%	1.8%	**14.0%**
																Storm	4	20056	55125.0	8	0.9%	2.9%	9.5%	**8.6%**
																Wildfire	0	4000	12000.0	3	0.0%	0.2%	0.8%	**3.2%**
											Chile	1.93%	16.74%	64.84%	**9.83%**	**Earthquake**	99	463215	5025776.7	6	57.3%	73.1%	96.8%	**13.0%**
																Epidemic	1	40	0.0	1	0.1%	0.0%	0.0%	**2.2%**
																Extreme temperature	1	15119	5000.0	4	0.2%	1.6%	0.1%	**8.7%**
																Flood	13	42134	26572.2	18	22.4%	20.0%	1.5%	**39.1%**
																Mass movement wet	141	82811	6000.0	1	13.6%	2.2%	0.0%	**2.2%**
																Storm	9	7127	0.0	6	4.9%	1.1%	0.0%	**13.0**

																								%
																Volcano	2	18763	3750.0	4	0.6%	2.0%	0.0%	**8.7%**
																Wildfire	2	264	80000.0	6	1.0%	0.0%	1.5%	**13.0%**
											Colombia	6.48%	16.92%	4.14%	**18.80%**	**Earthquake**	119	98309	143828.2	13	44.1%	33.3%	94.1%	**14.8%**
																Epidemic	206	8569	0.0	2	11.8%	0.4%	0.0%	**2.3%**
																Flood	18	65543	342.2	38	19.3%	64.8%	0.7%	**43.2%**
																Insect infestation	0	0	104000.0	1	0.0%	0.0%	5.2%	**1.1%**
																Mass movement dry	44	1206	0.0	2	2.5%	0.1%	0.0%	**2.3%**
																Mass movement wet	37	416	20.0	20	21.4%	0.2%	0.0%	**22.7%**
																Storm	2	3591	166.7	3	0.2%	0.3%	0.0%	**3.4%**
																Volcano	4	4838	0.0	7	0.7%	0.9%	0.0%	**8.0%**
																Wildfire	0	0	0.0	2	0.0%	0.0%	0.0%	**2.3%**
											Ecuador	2.45%	4.78%	3.48%	**7.05%**	**Earthquake**	7	8029	1400.0	5	2.8%	3.7%	0.4%	**15.2%**
																Epidemic	94	19792	0.0	6	42.6%	10.9%	0.0%	**18.2%**
																Flood	20	40933	125375.0	8	12.3%	30.1%	60.0%	**24.2%**
																Mass movement dry	60	0	0.0	1	4.5%	0.0%	0.0%	**3.0%**
																Mass movement wet	124	18863	125000.0	4	37.4%	6.9%	29.9%	**12.1%**
																Volcano	1	65548	20121.9	8	0.4%	48.3%	9.6%	**24.2%**
																Wildfire	0	0	0.0	1	0.0%	0.0%	0.0%	**3.0%**

											French Guiana	0.00%	0.31%	0.00%	**0.21%**	**Flood**	0	70000	0.0	1	100.0%	100.0%	100.0%	**100.0%**
											Guyana	0.08%	1.97%	1.32%	**1.07%**	**Flood**	9	111944	158525.0	4	77.3%	100.0%	100.0%	**80.0%**
																Mass movement wet	10	0	0.0	1	22.7%	0.0%	0.0%	**20.0%**
											Paraguay	0.18%	2.17%	0.02%	**2.78%**	**Extreme temperature**	8	0	0.0	1	8.3%	0.0%	0.0%	**7.7%**
																Flood	8	61482	1072.4	7	57.3%	87.2%	100.0%	**53.8%**
																Storm	7	12586	0.0	5	34.4%	12.8%	0.0%	**38.5%**
											Peru	24.17%	22.49%	1.98%	**13.89%**	**Earthquake**	69	83380	60070.0	15	8.0%	24.5%	94.7%	**23.1%**
																Epidemic	1736	52405	0.0	6	79.8%	6.2%	0.0%	**9.2%**
																Extreme temperature	182	919944	0.0	2	2.8%	36.0%	0.0%	**3.1%**
																Flood	21	71336	2272.7	22	3.5%	30.7%	5.3%	**33.8%**
																Insect infestation	0	0	0.0	1	0.0%	0.0%	0.0%	**1.5%**
																Mass movement wet	50	2600	0.0	14	5.3%	0.7%	0.0%	**21.5%**
																Storm	38	43341	0.0	2	0.6%	1.7%	0.0%	**3.1%**
																Volcano	0	3500	0.0	2	0.0%	0.1%	0.0%	**3.1%**
																Wildfire	0	1000	0.0	1	0.0%	0.0%	0.0%	**1.5%**

											Suriname	0.01%	0.14%	0.00%	**0.43%**	**Flood**	3	15774	0.0	2	100.0%	100.0%	100.0%	**100.0%**
											Uruguay	0.06%	0.77%	0.16%	**3.42%**	**Extreme temperature**	7	400	0.0	1	21.2%	0.2%	0.0%	**6.3%**
																Flood	2	18889	5555.6	9	45.5%	96.9%	66.7%	**56.3%**
																Storm	2	852	4166.7	6	33.3%	2.9%	33.3%	**37.5%**
											Venezuela	56.65%	3.88%	7.25%	**6.62%**	**Earthquake**	80	4183	81000.0	1	0.3%	0.5%	2.3%	**3.2%**
																Epidemic	31	10688	0.0	4	0.4%	4.8%	0.0%	**12.9%**
																Flood	1375	37583	154545.5	22	98.9%	93.8%	97.5%	**71.0%**
																Mass movement wet	18	518	0.0	1	0.1%	0.1%	0.0%	**3.2%**
																Storm	38	2543	1500.0	3	0.4%	0.9%	0.1%	**9.7%**
	Asia	**68.71%**	**92.11%**	**48.92%**	**40.80%**	**Central Asia**	**0.27%**	**0.11%**	**0.17%**	**3.32%**	**Kazakhstan**	6.54%	29.40%	16.36%	**17.20%**	**Earthquake**	3	36626	0.0	1	1.6%	4.9%	0.0%	**6.3%**
																Epidemic	2	291	0.0	3	3.8%	0.1%	0.0%	**18.8%**
																Extreme temperature	2	300006	0.0	2	1.6%	80.1%	0.0%	**12.5%**
																Flood	2	14738	34670.6	7	7.0%	13.8%	98.8%	**43.8%**
																Mass movement wet	48	0	0.0	1	25.8%	0.0%	0.0%	**6.3%**
																Storm	112	0	3000.0	1	60.2%	0.0%	1.2%	**6.3%**
																Wildfire	0	8000	0.0	1	0.0%	1.1%	0.0%	**6.3%**
											Kyrgyzstan	14.69%	9.19%	13.70%	**22.58%**	**Earthquake**	19	22040	23285.7	7	31.6%	66.0%	79.2%	**33.3%**
																Epidemic	11	397	0.0	2	5.3%	0.3%	0.0%	**9.5%**

																Extreme temperature	11	0	0.0	1	2.6%	0.0%	0.0%	**4.8%**
																Flood	1	3541	1753.3	3	1.0%	4.5%	2.6%	**14.3%**
																Mass movement wet	31	8520	4687.5	8	59.6%	29.1%	18.2%	**38.1%**
											Tajikistan	75.33%	35.78%	59.96%	**50.54%**	**Earthquake**	2	4750	2937.5	8	0.8%	4.2%	2.6%	**17.0%**
																Epidemic	86	7909	0.0	2	8.0%	1.7%	0.0%	**4.3%**
																Flood	72	34431	30090.5	22	74.1%	83.1%	73.5%	**46.8%**
																Insect infestation	0	0	0.0	1	0.0%	0.0%	0.0%	**2.1%**
																Mass movement dry	12	0	0.0	1	0.6%	0.0%	0.0%	**2.1%**
																Mass movement wet	32	8853	19518.2	11	16.6%	10.7%	23.8%	**23.4%**
																Storm	0	1165	217.0	2	0.0%	0.3%	0.0%	**4.3%**
											Turkmenistan	0.39%	0.02%	6.65%	**2.15%**	**Earthquake**	11	0	0.0	1	100.0%	0.0%	0.0%	**50.0%**
																Flood	0	420	99870.0	1	0.0%	100.0%	100.0%	**50.0%**
											Uzbekistan	3.06%	25.61%	3.33%	**7.53%**	**Drought**	0	600000	50000.0	1	0.0%	92.0%	100.0%	**14.3%**
																Earthquake	11	25043	0.0	2	25.3%	7.7%	0.0%	**28.6%**
																Epidemic	40	148	0.0	1	46.0%	0.0%	0.0%	**14.3%**
																Flood	0	1500	0.0	1	0.0%	0.2%	0.0%	**14.3%**
																Mass movement dry	1	400	0.0	1	1.1%	0.1%	0.0%	**14.3%**
																Mass	24	0	0.0	1	27.6	0.0%	0.0%	**14.3**

																movement wet					%			**%**
						Eastern Asia	**15.21%**	**66.18%**	**81.20%**	**27.35%**	**China P Rep**	78.18%	98.69%	34.22%	**61.18%**	**Drought**	0	24000000	26600.0	2	0.0%	3.1%	0.0%	**0.4%**
																Earthquake	1029	753541	999693.3	89	74.3%	4.3%	35.8%	**19.0%**
																Epidemic	538	500	0.0	2	0.9%	0.0%	0.0%	**0.4%**
																Extreme temperature	39	10129894	2672625.0	8	0.3%	5.2%	8.6%	**1.7%**
																Flood	117	6637586	627810.8	143	13.6%	60.9%	36.1%	**30.6%**
																Insect infestation	0	0	0.0	1	0.0%	0.0%	0.0%	**0.2%**
																Mass movement dry	35	1095	0.0	5	0.1%	0.0%	0.0%	**1.1%**
																Mass movement wet	93	46473	39370.2	47	3.5%	0.1%	0.7%	**10.0%**
																Storm	54	2456750	280248.5	167	7.3%	26.3%	18.7%	**35.7%**
																Wildfire	19	76	0.0	4	0.1%	0.0%	0.0%	**0.9%**
											Hong Kong (China)	0.08%	0.00%	0.07%	**3.01%**	**Flood**	22	1411	24250.0	4	67.2%	20.5%	18.3%	**17.4%**
																Mass movement wet	1	65	790.0	1	0.8%	0.2%	0.1%	**4.3%**
																Storm	2	1210	24000.0	18	32.0%	79.2%	81.5%	**78.3%**
											Japan	17.03%	0.20%	57.56%	**15.16%**	**Earthquake**	1061	46653	14815100.0	24	94.9%	35.8%	85.0%	**20.7%**
																Epidemic	0	460	0.0	1	0.0%	0.0%	0.0%	**0.9%**
																Extreme temperature	170	15000	0.0	1	0.6%	0.5%	0.0%	**0.9%**
																Flood	13	30950	663429.4	17	0.8%	16.8%	2.7%	**14.7%**
																Mass	21	77	26250.0	8	0.6%	0.0%	0.1%	**6.9%**

					movement wet							
					Storm	13	23564	864484.7	59	2.9%	44.5%	12.2%	**50.9%**
					Volcano	9	14270	2000.0	5	0.2%	2.3%	0.0%	**4.3%**
					Wildfire	0	222	0.0	1	0.0%	0.0%	0.0%	**0.9%**
Korea Dem P Rep	1.05%	0.76%	3.26%	**3.53%**	**Epidemic**	0	200	0.0	1	0.0%	0.0%	0.0%	**3.7%**
					Flood	83	599082	922705.3	19	94.9%	94.3%	74.2%	**70.4%**
					Storm	12	97890	872930.0	7	5.1%	5.7%	25.8%	**25.9%**
Korea Rep	1.21%	0.07%	1.90%	**7.45%**	**Epidemic**	0	177	0.0	2	0.0%	0.0%	0.0%	**3.5%**
					Extreme temperature	40	0	0.0	1	2.1%	0.0%	0.0%	**1.8%**
					Flood	48	36843	124106.9	21	52.9%	74.5%	18.9%	**36.8%**
					Mass movement wet	30	1229	36233.3	3	4.6%	0.4%	0.8%	**5.3%**
					Storm	29	9471	410442.9	27	40.3%	24.6%	80.3%	**47.4%**
					Wildfire	1	1717	0.0	3	0.1%	0.5%	0.0%	**5.3%**
Macau	0.00%	0.00%	0.00%	**0.65%**	**Epidemic**	0	1	0.0	1	0.0%	0.0%	0.0%	**20.0%**
					Storm	0	997	0.0	4	0.0%	100.0%	0.0%	**80.0%**
Mongolia	0.13%	0.06%	0.25%	**1.96%**	**Epidemic**	4	59	0.0	2	3.9%	0.0%	0.0%	**13.3%**
					Flood	17	4130	72.8	5	42.6%	2.4%	0.0%	**33.3%**
					Storm	17	141000	1666.7	6	41.2%	97.0%	0.5%	**40.0%**
					Wildfire	13	2531	911400.0	2	12.3%	0.6%	99.4%	**13.3%**
n (Ch	2.3 2%	0.2 2%	2.7 3%	**7.0 6%**	**Earthquake**	454	21911	302516	5	62.0	3.1%	76.2	**9.3%**

																			0.0		%		%	
																Flood	8	825	63857.5	4	0.9%	0.1%	1.3%	**7.4%**
																Storm	30	75489	99450.2	45	37.1%	96.8%	22.5%	**83.3%**
						South-Eastern Asia	**36.24%**	**7.28%**	**5.38%**	**30.39%**	**Cambodia**	0.45%	3.99%	0.80%	**2.12%**	**Epidemic**	119	79269	0.0	5	35.4%	5.7%	0.0%	**27.8%**
																Flood	105	636143	38300.0	10	62.0%	91.7%	100.0%	**55.6%**
																Storm	15	59364	3.3	3	2.6%	2.6%	0.0%	**16.7%**
											Indonesia	49.65%	9.66%	47.70%	**27.65%**	**Drought**	0	15000	1000.0	1	0.0%	0.1%	0.0%	**0.4%**
																Earthquake	2794	130233	177150.4	64	95.9%	49.6%	49.4%	**27.2%**
																Epidemic	123	3342	0.0	18	1.2%	0.4%	0.0%	**7.7%**
																Flood	41	54187	25473.4	86	1.9%	27.8%	9.5%	**36.6%**
																Mass movement wet	37	10553	3440.1	35	0.7%	2.2%	0.5%	**14.9%**
																Storm	2	1858	0.0	2	0.0%	0.0%	0.0%	**0.9%**
																Volcano	18	14110	409.1	22	0.2%	1.8%	0.0%	**9.4%**
																Wildfire	35	433467	1328828.6	7	0.1%	18.1%	40.5%	**3.0%**
											Lao P Dem Rep	0.23%	2.46%	0.89%	**2.59%**	**Epidemic**	144	3586	0.0	5	81.9%	0.4%	0.0%	**22.7%**
																Flood	7	235645	1902.3	12	9.9%	66.0%	5.3%	**54.5%**
																Storm	14	287240	81190.2	5	8.2%	33.5%	94.7%	**22.7%**
											Malaysia	0.25%	0.27%	3.23%	**5.18%**	**Earthquake**	80	5063	500000.0	1	8.6%	1.1%	32.2%	**2.3%**
																Epidemic	48	891	0.0	6	30.6%	1.1%	0.0%	**13.6%**
																Flood	5	16978	41708.3	24	13.4	86.9	64.4	**54.5**

																					%	%	%	**%**
															Mass movement dry	72	0	0.0	1	7.7%	0.0%	0.0%	**2.3%**
															Mass movement wet	24	73	0.0	4	10.3%	0.1%	0.0%	**9.1%**
															Storm	46	7991	8833.3	6	29.4%	10.2%	3.4%	**13.6%**
															Wildfire	0	1500	0.0	2	0.0%	0.6%	0.0%	**4.5%**
											Myanmar	37.10%	2.22%	9.78%	**2.94%**	**Earthquake**	36	9284	125900.0	4	0.1%	1.0%	10.7%	**16.0%**
															Flood	32	65393	10511.9	13	0.3%	22.0%	2.9%	**52.0%**
															Mass movement wet	36	48789	0.0	3	0.1%	3.8%	0.0%	**12.0%**
															Storm	27740	566025	813537.6	5	99.5%	73.2%	86.4%	**20.0%**
											Philippines	6.86%	56.50%	13.37%	**35.18%**	**Drought**	0	0	453.0	1	0.0%	0.0%	0.0%	**0.3%**
															Earthquake	252	197722	37779.8	10	9.8%	2.0%	5.9%	**3.3%**
															Epidemic	44	1819	0.0	7	1.2%	0.0%	0.0%	**2.3%**
															Flood	19	135234	12412.4	93	6.7%	12.8%	17.9%	**31.1%**
															Insect infestation	0	200	0.0	1	0.0%	0.0%	0.0%	**0.3%**
															Mass movement dry	11	0	0.0	1	0.0%	0.0%	0.0%	**0.3%**
															Mass movement wet	85	4913	1314.1	20	6.6%	0.1%	0.4%	**6.7%**
															Storm	125	543916	31067.8	151	73.2%	83.7%	72.4%	**50.5%**
															Volcano	46	96479	15413.9	14	2.5%	1.4%	3.4%	**4.7%**
															Wildfire	2	300	0.0	1	0.0%	0.0%	0.0%	**0.3%**

											Singapore	0.00%	0.00%	0.00%	**0.12%**	**Epidemic**	2	2022	0.0	1	100.0%	100.0%	100.0%	**100.0%**
											Thailand	2.63%	9.36%	9.47%	**9.29%**	**Drought**	0	0	2000.0	1	0.0%	0.0%	0.0%	**1.3%**
																Earthquake	2782	22341	333333.3	3	84.6%	0.4%	21.9%	**3.8%**
																Epidemic	89	1946	0.0	1	0.9%	0.0%	0.0%	**1.3%**
																Flood	23	276060	71147.2	44	10.1%	74.7%	68.7%	**55.7%**
																Mass movement wet	16	14370	0.0	3	0.5%	0.3%	0.0%	**3.8%**
																Storm	14	147908	15816.3	27	3.9%	24.6%	9.4%	**34.2%**
											Timor-Leste	0.00%	0.00%	0.00%	**0.24%**	**Flood**	2	1554	0.0	2	100.0%	100.0%	100.0%	**100.0%**
											Viet Nam	2.83%	15.53%	14.76%	**14.71%**	**Epidemic**	120	4427	0.0	4	4.5%	0.1%	0.0%	**3.2%**
																Flood	57	260270	54602.5	51	27.3%	49.2%	39.2%	**40.8%**
																Mass movement wet	55	6512	383.3	6	3.1%	0.1%	0.0%	**4.8%**
																Storm	110	216626	68557.2	63	65.1%	50.6%	60.8%	**50.4%**
																Wildfire	0	0	0.0	1	0.0%	0.0%	0.0%	**0.8%**
						Southern Asia	**46.07%**	**26.03%**	**9.18%**	**31.86%**	Afghanistan	3.81%	0.24%	0.10%	**11.78%**	**Earthquake**	377	20057	872.2	23	47.6%	31.3%	23.9%	**21.9%**
																Epidemic	371	819	0.0	9	18.4%	0.5%	0.0%	**8.6%**
																Extreme temperature	315	61814	1.7	6	10.4%	25.2%	0.0%	**5.7%**

																Flood	63	6385	1230.8	52	18.0%	22.5%	76.1%	**49.5%**
																Insect infestation	0	0	0.0	1	0.0%	0.0%	0.0%	**1.0%**
																Mass movement dry	100	0	0.0	1	0.5%	0.0%	0.0%	**1.0%**
																Mass movement wet	89	30174	0.0	10	4.9%	20.5%	0.0%	**9.5%**
																Storm	16	3	0.0	2	0.2%	0.0%	0.0%	**1.9%**
																Wildfire	0	0	0.0	1	0.0%	0.0%	0.0%	**1.0%**
											Bangladesh	32.59%	15.04%	8.72%	**18.52%**	**Earthquake**	7	3785	100000.0	5	0.0%	0.0%	7.0%	**3.0%**
																Epidemic	295	143782	0.0	12	2.3%	1.8%	0.0%	**7.3%**
																Extreme temperature	55	3800	0.0	10	0.4%	0.0%	0.0%	**6.1%**
																Flood	68	1156710	29325.5	47	2.0%	58.2%	19.3%	**28.5%**
																Mass movement wet	32	18427	0.0	3	0.1%	0.1%	0.0%	**1.8%**
																Storm	1685	422757	59971.6	88	95.2%	39.8%	73.8%	**53.3%**
											Bhutan	0.06%	0.01%	0.00%	**0.79%**	**Earthquake**	6	10014	0.0	2	4.6%	23.1%	0.0%	**28.6%**
																Flood	111	800	0.0	2	84.4%	1.8%	0.0%	**28.6%**
																Storm	15	32500	0.0	2	11.0%	75.0%	0.0%	**28.6%**
																Wildfire	0	0	3500.0	1	0.0%	0.0%	100.0%	**14.3%**
											India	21.30%	73.05%	46.71%	**33.22%**	**Drought**	0	0	542400.0	1	0.0%	0.0%	1.4%	**0.3%**
																Earthquake	4921	842765	502480.0	10	48.4%	1.9%	13.1%	**3.4%**

					Epidemic	64	5157	0.0	29	1.8%	0.0%	0.0%	**9.8%**
					Extreme temperature	414	1	22222.2	18	7.3%	0.0%	1.0%	**6.1%**
					Flood	151	2809625	163705.3	144	21.4%	89.2%	61.5%	**48.6%**
					Insect infestation	0	0	0.0	1	0.0%	0.0%	0.0%	**0.3%**
					Mass movement wet	70	49400	2018.5	27	1.9%	0.3%	0.1%	**9.1%**
					Storm	300	600545	134608.3	65	19.1%	8.6%	22.8%	**22.0%**
					Wildfire	6	0	0.0	1	0.0%	0.0%	0.0%	**0.3%**
Iran Islam Rep	15.26%	0.69%	18.66%	**12.57%**	Earthquake	1413	35181	187672.6	50	97.0%	40.9%	61.2%	**44.6%**
					Epidemic	76	0	0.0	1	0.1%	0.0%	0.0%	**0.9%**
					Flood	41	48209	120602.6	49	2.8%	54.9%	38.6%	**43.8%**
					Mass movement wet	24	15	0.0	3	0.1%	0.0%	0.0%	**2.7%**
					Storm	6	22474	3567.5	8	0.1%	4.2%	0.2%	**7.1%**
					Wildfire	0	0	0.0	1	0.0%	0.0%	0.0%	**0.9%**
Maldives	0.02%	0.01%	0.61%	**0.34%**	Earthquake	102	27214	470100.0	1	100.0%	51.6%	94.0%	**33.3%**
					Flood	0	1649	0.0	1	0.0%	3.1%	0.0%	**33.3%**
					Storm	0	23849	30000.0	1	0.0%	45.2%	6.0%	**33.3%**
Nepal	1.54%	0.44%	0.34%	**5.84%**	Earthquake	4	84117	0.0	2	0.1%	6.1%	0.0%	**3.8%**
					Epidemic	221	7435	0.0	14	42.1%	3.8%	0.0%	**26.9%**
					Extreme temperature	51	100	61.5	2	1.4%	0.0%	0.0%	**3.8%**
					Flood	157	10879	14447.4	19	40.7	74.9	97.7	**36.5**

																	9			%	%	%	**%**
															Mass movement wet	95	33420	0.0	11	14.2 %	13.3 %	0.0%	**21.2 %**
															Storm	13	92	0.0	2	0.4%	0.0%	0.0%	**3.8%**
															Wildfire	44	27000	3100.0	2	1.2%	2.0%	2.2%	**3.8%**
											Pakistan	17.86%	8.94%	22.12%	**Earthquake**	4933	433721	348100.0	15	86.8 %	11.7 %	28.8 %	**14.0 %**
														12.01%	**Epidemic**	34	1717	0.0	6	0.2%	0.0%	0.0%	**5.6%**
															Extreme temperature	102	43	0.0	11	1.3%	0.0%	0.0%	**10.3 %**
															Flood	182	1039693	249030.6	45	9.6%	84.3 %	61.7 %	**42.1 %**
															Insect infestation	0	0	0.0	1	0.0%	0.0%	0.0%	**0.9%**
															Mass movement wet	30	2121	1125.0	16	0.6%	0.1%	0.1%	**15.0 %**
															Storm	99	168726	131610.5	13	1.5%	3.9%	9.4%	**12.1 %**
											Sri Lanka	7.57%	1.56%	2.73%	**Earthquake**	35399	1019306	1316500.0	1	97.9 %	10.5 %	58.8 %	**2.3%**
														4.94%	**Epidemic**	30	7016	0.0	3	0.3%	0.2%	0.0%	**6.8%**
															Flood	16	228207	26398.0	36	1.5%	84.6 %	41.2 %	**81.8 %**
															Mass movement wet	65	130	0.0	1	0.2%	0.0%	0.0%	**2.3%**
															Storm	12	153347	0.0	3	0.1%	4.7%	0.0%	**6.8%**
						Western Asia	**2.21%**	**0.39%**	**4.07%**	**7.08%**	**Armenia**	0.02%	0.24%	0.11%	**Earthquake**	0	15000	33333.0	1	0.0%	67.7 %	80.4 %	**25.0 %**
														2.02%	**Flood**	2	2381	2706.7	3	100.0%	32.3 %	19.6 %	**75.0 %**
											Azerbaijan	0.28 %	26.94 %	0.15 %	**5.05 %**	**Earthquake**	11	237491	5000.0	3	52.4 %	28.3 %	26.7 %	**30.0 %**

					Flood	3	301467	6866.7	6	30.2%	71.7%	73.3%	**60.0%**
					Mass movement wet	11	0	0.0	1	17.5%	0.0%	0.0%	**10.0%**
Cyprus	0.26%	0.03%	0.04%	**3.03%**	Earthquake	2	1865	4340.0	1	3.4%	77.5%	30.3%	**16.7%**
					Extreme temperature	29	250	0.0	2	96.6%	20.8%	0.0%	**33.3%**
					Storm	0	20	5000.0	2	0.0%	1.7%	69.7%	**33.3%**
					Wildfire	0	0	0.0	1	0.0%	0.0%	0.0%	**16.7%**
Georgia	0.14%	0.39%	1.05%	**7.07%**	Earthquake	4	7553	87500.0	4	48.4%	82.0%	91.2%	**28.6%**
					Flood	2	638	3761.8	9	51.6%	15.6%	8.8%	**64.3%**
					Storm	0	900	0.0	1	0.0%	2.4%	0.0%	**7.1%**
Iraq	0.23%	0.79%	0.00%	**4.55%**	Drought	0	0	0.0	1	0.0%	0.0%	0.0%	**11.1%**
					Earthquake	20	500	0.0	1	38.5%	0.7%	0.0%	**11.1%**
					Epidemic	0	185	0.0	1	0.0%	0.2%	0.0%	**11.1%**
					Flood	5	12252	216.7	6	61.5%	99.1%	100.0%	**66.7%**
Israel	0.30%	0.23%	2.49%	**4.55%**	Extreme temperature	0	0	275000.0	2	0.0%	0.0%	60.6%	**22.2%**
					Flood	6	333	13333.3	3	24.6%	4.6%	4.4%	**33.3%**
					Storm	4	205	1375.0	2	11.6%	1.9%	0.3%	**22.2%**
					Wildfire	22	10131	157500.0	2	63.8%	93.5%	34.7%	**22.2%**
da	0.18%	0.19%	1.10%	**3.54%**	Extreme	8	6	200000.	2	36.6	0.1%	99.8	**28.6**

					temperature			0		%		%	**%**
					Flood	5	9000	500.0	2	24.4%	98.7%	0.2%	**28.6%**
					Storm	5	75	0.0	3	39.0%	1.2%	0.0%	**42.9%**
Kuwait	0.01%	0.00%	0.00%	**1.01%**	**Epidemic**	0	1	0.0	1	0.0%	0.5%	0.0%	**50.0%**
					Flood	2	200	0.0	1	100.0%	99.5%	0.0%	**50.0%**
Lebanon	0.11%	1.30%	0.43%	**2.02%**	**Flood**	0	17000	0.0	1	0.0%	14.0%	0.0%	**25.0%**
					Storm	13	52288	77500.0	2	96.2%	86.0%	100.0%	**50.0%**
					Wildfire	1	15	0.0	1	3.8%	0.0%	0.0%	**25.0%**
Oman	0.62%	0.22%	13.59%	**2.53%**	**Storm**	29	4057	990200.0	5	100.0%	100.0%	100.0%	**100.0%**
Palestine (West Bank)	0.00%	0.01%	0.00%	**1.01%**	**Flood**	0	250	0.0	2	100.0%	100.0%	100.0%	**100.0%**
Saudi Arabia	1.62%	0.26%	3.29%	**5.56%**	**Epidemic**	76	329	0.0	1	20.5%	1.4%	0.0%	**9.1%**
					Flood	30	2363	120000.0	10	79.5%	98.6%	100.0%	**90.9%**
n Arab	0.52%	0.00%	0.00%	**2.02%**	**Flood**	6	0	0.0	1	5.1%	0.0%	0.0%	**25.0%**

																Mass movement wet	80	23	0.0	1	67.8%	6.1%	0.0%	**25.0%**
																Storm	16	176	0.0	2	27.1%	93.9%	0.0%	**50.0%**
											Turkey	91.53%	65.23%	73.32%	**40.91%**	Earthquake	640	140834	790638.7	31	94.6%	71.5%	91.7%	**38.3%**
																Extreme temperature	13	2075	250.0	4	0.2%	0.1%	0.0%	**4.9%**
																Flood	18	63475	80759.3	27	2.3%	28.1%	8.2%	**33.3%**
																Mass movement dry	261	1069	0.0	1	1.2%	0.0%	0.0%	**1.2%**
																Mass movement wet	37	1838	3714.3	7	1.2%	0.2%	0.1%	**8.6%**
																Storm	10	234	0.0	7	0.3%	0.0%	0.0%	**8.6%**
																Wildfire	1	288	0.0	4	0.0%	0.0%	0.0%	**4.9%**
											Yemen	4.19%	4.17%	4.42%	**15.15%**	Earthquake	10	40039	0.0	1	1.0%	10.3%	0.0%	**3.3%**
																Epidemic	32	289	0.0	1	3.3%	0.1%	0.0%	**3.3%**
																Flood	35	15223	70065.2	23	83.9%	89.7%	100.0%	**76.7%**
																Mass movement wet	38	6	0.0	2	7.9%	0.0%	0.0%	**6.7%**
																Storm	15	0	0.0	2	3.1%	0.0%	0.0%	**6.7%**
																Volcano	6	15	0.0	1	0.6%	0.0%	0.0%	**3.3%**
	Europe	**4.75%**	**0.75%**	**11.54%**	**14.26%**	**Eastern Europe**	**11.96%**	**56.48%**	**10.64%**	**35.69%**	**Belarus**	0.23%	0.59%	0.79%	**2.40%**	Epidemic	7	444	0.0	2	65.0%	1.4%	0.0%	**25.0%**
																Extreme temperature	0	0	30300.0	1	0.0%	0.0%	17.1%	**12.5%**
																Flood	1	14000	34793.3	3	10.0%	65.3%	58.7%	**37.5%**
																Storm	3	10695	21500.0	2	25.0%	33.3%	24.2%	**25.0%**

											Bulgaria	1.07%	0.18%	2.12%	**6.91%**	**Earthquake**	1	264	0.0	2	1.1%	2.6%	0.0%	**8.7%**
																Extreme temperature	7	86	12.5	4	30.4%	1.7%	0.0%	**17.4%**
																Flood	5	1215	41636.4	11	56.5%	66.0%	96.3%	**47.8%**
																Storm	1	1950	0.0	3	2.2%	28.9%	0.0%	**13.0%**
																Wildfire	3	56	5866.7	3	9.8%	0.8%	3.7%	**13.0%**
											Czech Rep	1.11%	2.94%	22.88%	**5.11%**	**Flood**	7	26861	409630.0	12	89.5%	100.0%	95.7%	**70.6%**
																Storm	2	2	44000.0	5	10.5%	0.0%	4.3%	**29.4%**
											Hungary	1.67%	1.37%	4.42%	**5.11%**	**Drought**	0	0	100000.0	1	0.0%	0.0%	10.1%	**5.9%**
																Extreme temperature	81	0	0.0	1	56.6%	0.0%	0.0%	**5.9%**
																Flood	1	12460	73450.0	12	7.0%	99.8%	88.9%	**70.6%**
																Storm	17	100	3333.3	3	36.4%	0.2%	1.0%	**17.6%**
											Moldova Rep	0.92%	24.41%	1.76%	**3.60%**	**Drought**	2	0	0.0	1	2.5%	0.0%	0.0%	**8.3%**
																Epidemic	0	1647	0.0	1	0.0%	0.1%	0.0%	**8.3%**
																Extreme temperature	13	0	0.0	1	16.5%	0.0%	0.0%	**8.3%**
																Flood	9	7422	51797.7	7	77.2%	1.9%	92.0%	**58.3%**
																Storm	2	1312790	15800.0	2	3.8%	98.0%	8.0%	**16.7%**
											Poland	11.19%	3.17%	33.82%	**7.51%**	**Extreme temperature**	134	0	0.0	6	83.9%	0.0%	0.0%	**24.0%**
																Flood	13	38472	820000.0	9	11.8%	99.7%	97.2%	**36.0%**

					Storm	4	114	21115.0	10	4.4%	0.3%	2.8%	**40.0 %**
Romania	8.99%	3.59%	8.56%	**18.32%**	**Earthquake**	3	2183	0.0	3	1.2%	1.7%	0.0%	**4.9%**
					Epidemic	0	2372	0.0	2	0.0%	1.2%	0.0%	**3.3%**
					Extreme temperature	24	194	0.0	13	40.1 %	0.6%	0.0%	**21.3 %**
					Flood	12	10914	56523.2	34	53.4 %	94.3 %	100. 0%	**55.7 %**
					Mass movement wet	0	330	0.0	1	0.0%	0.1%	0.0%	**1.6%**
					Storm	5	1057	0.0	8	5.3%	2.1%	0.0%	**13.1 %**
Russia	59.93%	38.06%	15.53%	**39.64%**	**Drought**	0	500000	0.0	2	0.0%	23.9 %	0.0%	**1.5%**
					Earthquake	202	6019	55152.0	10	39.3 %	1.4%	15.8 %	**7.6%**
					Epidemic	3	15825	0.0	10	0.6%	3.8%	0.0%	**7.6%**
					Extreme temperature	110	47333	6.3	16	34.2 %	18.1 %	0.0%	**12.1 %**
					Flood	12	46274	53629.1	47	11.0 %	52.1 %	72.3 %	**35.6 %**
					Insect infestation	0	0	0.0	1	0.0%	0.0%	0.0%	**0.8%**
					Mass movement dry	30	875	1300.0	2	1.2%	0.0%	0.1%	**1.5%**
					Mass movement wet	59	115	0.0	7	8.1%	0.0%	0.0%	**5.3%**
					Storm	11	1120	15739.5	19	4.1%	0.5%	8.6%	**14.4 %**
					Wildfire	5	162	6296.4	18	1.6%	0.1%	3.3%	**13.6 %**
Slovakia	0.83 %	0.54 %	2.83 %	**3.90 %**	**Extreme temperature**	0	0	0.0	1	0.0%	0.0%	0.0%	**7.7%**

										Flood	6	4900	25230.0	10	88.7%	82.6%	39.7%	**76.9%**
										Storm	2	10324	383300.0	1	2.8%	17.4%	60.3%	**7.7%**
										Wildfire	6	0	0.0	1	8.5%	0.0%	0.0%	**7.7%**
					Ukraine	14.06%	25.16%	7.30%	**7.51%**	**Epidemic**	92	2257	0.0	3	22.8%	0.2%	0.0%	**12.0%**
										Extreme temperature	276	19867	28333.3	3	68.7%	2.2%	5.2%	**12.0%**
										Flood	7	219858	108167.8	12	6.8%	95.5%	79.2%	**48.0%**
										Storm	3	8095	36514.3	7	1.7%	2.1%	15.6%	**28.0%**
Northern Europe	**0.68%**	**7.56%**	**17.60%**	**12.47%**	**Denmark**	2.67%	0.00%	11.30%	**6.56%**	**Storm**	2	0	524367.4	8	100.0%	100.0%	100.0%	**100.0%**
					Estonia	0.00%	0.01%	0.35%	**0.82%**	**Storm**	0	100	130000.0	1	100.0%	100.0%	100.0%	**100.0%**
					Finland	0.00%	0.03%	0.03%	**2.46%**	**Flood**	0	400	0.0	1	0.0%	100.0%	0.0%	**33.3%**
										Storm	0	0	5000.0	2	0.0%	0.0%	100.0%	**66.7%**
					Iceland	7.00%	0.02%	0.09%	**4.10%**	**Earthquake**	0	100	6000.0	2	0.0%	70.6%	35.0%	**40.0%**
										Mass movement wet	17	42	2894.5	2	100.0%	29.4%	16.9%	**40.0%**
										Volcano	0	0	16500.0	1	0.0%	0.0%	48.1%	**20.0%**
					Ireland	4.12%	0.31%	1.83%	**13.93%**	**Epidemic**	0	1	0.0	1	0.0%	0.0%	0.0%	**5.9%**
										Flood	1	1100	90750.0	4	25.0%	95.6%	53.5%	**23.5%**

															Storm	1	17	26254.2	12	75.0%	4.3%	46.5%	**70.6%**
											Latvia	5.56%	0.01%	0.88%	**4.10%**	**Epidemic**	0	102	0.0	1	0.0%	100.0%	0.0%	**20.0%**
																Extreme temperature	21	0	0.0	1	77.8%	0.0%	0.0%	**20.0%**
																Storm	2	0	108500.0	3	22.2%	0.0%	100.0%	**60.0%**
											Lithuania	14.20%	53.12%	0.24%	**7.38%**	**Drought**	0	0	52900.0	1	0.0%	0.0%	60.1%	**11.1%**
																Extreme temperature	19	0	0.0	3	82.6%	0.0%	0.0%	**33.3%**
																Flood	2	0	0.0	2	5.8%	0.0%	0.0%	**22.2%**
																Storm	3	260000	11700.0	3	11.6%	100.0%	39.9%	**33.3%**
											Norway	1.03%	0.46%	1.52%	**8.20%**	**Flood**	0	2033	100000.0	3	20.0%	91.0%	53.3%	**30.0%**
																Storm	1	86	37571.4	7	80.0%	9.0%	46.7%	**70.0%**
											Sweden	2.26%	0.02%	8.00%	**5.74%**	**Epidemic**	0	175	0.0	2	0.0%	100.0%	0.0%	**28.6%**
																Storm	2	0	594000.0	5	100.0%	0.0%	100.0%	**71.4%**
											United Kingdom	63.17%	46.03%	75.77%	**46.72%**	**Earthquake**	0	2251	30000.0	2	0.0%	0.7%	0.2%	**3.5%**
																Epidemic	0	4	0.0	1	0.0%	0.0%	0.0%	**1.8%**
																Extreme temperature	3	8	0.0	6	5.9%	0.0%	0.0%	**10.5%**
																Flood	2	16642	702314.3	23	14.0%	56.6%	57.4%	**40.4%**
																Storm	10	11539	476278.0	25	80.1%	42.7%	42.3%	**43.9%**
						ern Euro	**51.66%**	**8.90%**	**28.19%**	**24.95%**	**Albania**	0.07%	38.05%	0.04%	**5.74%**	**Earthquake**	0	1125	0.0	2	0.0%	0.3%	0.0%	**14.3%**

					Epidemic	0	226	0.0	1	0.0%	0.0%	0.0%	**7.1%**
					Extreme temperature	0	150	0.0	1	0.0%	0.0%	0.0%	**7.1%**
					Flood	2	16298	3084.1	8	70.4%	19.8%	100.0%	**57.1%**
					Storm	4	262500	0.0	2	29.6%	79.8%	0.0%	**14.3%**
Azores	0.11%	0.07%	0.26%	**1.23%**	**Earthquake**	10	1100	72000.0	1	25.6%	90.5%	46.7%	**33.3%**
					Mass movement wet	29	55	16300.0	1	74.4%	4.5%	10.6%	**33.3%**
					Storm	0	60	66000.0	1	0.0%	4.9%	42.8%	**33.3%**
Bosnia-Hercegovenia	0.02%	19.12%	0.15%	**5.33%**	**Epidemic**	0	400	0.0	1	0.0%	0.1%	0.0%	**7.7%**
					Extreme temperature	0	0	0.0	1	0.0%	0.0%	0.0%	**7.7%**
					Flood	0	41093	10875.0	8	33.3%	99.4%	100.0%	**61.5%**
					Mass movement wet	6	403	0.0	1	66.7%	0.1%	0.0%	**7.7%**
					Storm	0	1090	0.0	1	0.0%	0.3%	0.0%	**7.7%**
					Wildfire	0	0	0.0	1	0.0%	0.0%	0.0%	**7.7%**
Canary Is	0.15%	0.05%	1.46%	**2.05%**	**Extreme temperature**	13	113	0.0	1	23.6%	13.4%	0.0%	**20.0%**
					Flood	12	365	39961.5	2	41.8%	86.6%	9.2%	**40.0%**
					Storm	10	0	395000.0	2	34.5%	0.0%	90.8%	**40.0%**
Croatia	0.16%	0.30%	1.16%	**5.74%**	**Drought**	0	0	330000.0	1	0.0%	0.0%	48.0%	**7.1%**
					Earthquake	0	2000	0.0	1	0.0%	38.9%	0.0%	**7.1%**
					Extreme	23	100	120000.	2	77.6	3.9%	34.9	**14.3**

					temperature			0		%		%	**%**
					Flood	0	582	16000.0	5	0.0%	56.7 %	11.6 %	**35.7 %**
					Wildfire	3	5	7550.0	5	22.4 %	0.5%	5.5%	**35.7 %**
Greece	0.96%	10.19%	15.75%	**18.03%**	**Drought**	0	0	1000000.0	1	0.0%	0.0%	10.7 %	**2.3%**
					Earthquake	15	11739	390207.7	13	55.7 %	86.6 %	54.1 %	**29.5 %**
					Extreme temperature	16	88	1500.0	2	9.0%	0.1%	0.0%	**4.5%**
					Flood	2	791	66853.3	18	11.8 %	8.1%	12.8 %	**40.9 %**
					Storm	2	122	68000.0	5	2.2%	0.3%	3.6%	**11.4 %**
					Wildfire	15	1711	350000.0	5	21.3 %	4.9%	18.7 %	**11.4 %**
Italy	56.40%	12.26%	61.88%	**23.36%**	**Earthquake**	40	11944	1042472.4	9	1.7%	50.7 %	25.5 %	**15.8 %**
					Epidemic	2	5001	0.0	2	0.0%	4.7%	0.0%	**3.5%**
					Extreme temperature	4022	0	880000.0	5	96.3 %	0.0%	12.0 %	**8.8%**
					Flood	8	3422	853054.2	24	1.0%	38.7 %	55.6 %	**42.1 %**
					Mass movement wet	42	986	7175.0	4	0.8%	1.9%	0.1%	**7.0%**
					Storm	6	158	241714.3	7	0.2%	0.5%	4.6%	**12.3 %**
					Volcano	0	3500	1550.0	2	0.0%	3.3%	0.0%	**3.5%**
					Wildfire	1	75	205000.0	4	0.0%	0.1%	2.2%	**7.0%**
donia	0.05 %	6.37 %	0.44 %	**3.69 %**	**Epidemic**	0	200	0.0	1	0.0%	0.2%	0.0%	**11.1 %**

					Extreme temperature	15	0	0.0	1	88.2%	0.0%	0.0%	**11.1%**
					Flood	0	18317	41433.3	6	11.8%	99.8%	94.8%	**66.7%**
					Wildfire	0	0	13563.0	1	0.0%	0.0%	5.2%	**11.1%**
Montenegro	0.00%	0.43%	0.00%	**1.23%**	Flood	0	2479	0.0	3	100.0%	100.0%	100.0%	**100.0%**
Portugal	0.26%	0.27%	2.79%	**4.92%**	Flood	8	539	170375.0	8	63.3%	94.1%	82.2%	**66.7%**
					Storm	12	90	98333.3	3	36.7%	5.9%	17.8%	**25.0%**
					Wildfire	0	0	0.0	1	0.0%	0.0%	0.0%	**8.3%**
Serbia	0.02%	2.78%	0.22%	**3.28%**	Earthquake	2	27030	132260.0	1	28.6%	56.3%	100.0%	**12.5%**
					Extreme temperature	2	250	0.0	2	42.9%	1.0%	0.0%	**25.0%**
					Flood	0	4096	0.0	5	28.6%	42.7%	0.0%	**62.5%**
Serbia Montenegro	0.05%	7.26%	0.00%	**4.92%**	Earthquake	1	100	0.0	1	5.6%	0.1%	0.0%	**8.3%**
					Extreme temperature	3	70	0.0	1	16.7%	0.1%	0.0%	**8.3%**
					Flood	2	13933	0.0	9	77.8%	99.9%	0.0%	**75.0%**
					Wildfire	0	12	0.0	1	0.0%	0.0%	0.0%	**8.3%**
Slovenia	0.02%	0.14%	0.68%	**2.05%**	Earthquake	1	653	5000.0	2	14.3%	55.4%	2.5%	**40.0%**
					Flood	0	0	5000.0	1	0.0%	0.0%	1.2%	**20.0%**
					Storm	3	525	196000.0	2	85.7%	44.6%	96.3%	**40.0%**

											Spain	41.71%	2.73%	13.87%	**17.62%**	**Earthquake**	5	7660	122002.0	2	0.1%	32.5%	3.0%	**4.7%**
																Epidemic	1	376	0.0	2	0.0%	1.6%	0.0%	**4.7%**
																Extreme temperature	3033	14	340860.0	5	98.2%	0.1%	20.7%	**11.6%**
																Flood	4	993	88683.5	13	0.3%	27.4%	14.0%	**30.2%**
																Mass movement wet	84	129	20000.0	1	0.5%	0.3%	0.2%	**2.3%**
																Storm	8	29	201500.0	12	0.6%	0.7%	29.3%	**27.9%**
																Wildfire	6	2203	339000.0	8	0.3%	37.4%	32.9%	**18.6%**
											Yugoslavia	0.02%	0.01%	1.29%	**0.82%**	**Earthquake**	8	120	0.0	1	100.0%	100.0%	0.0%	**50.0%**
																Flood	0	0	766100.0	1	0.0%	0.0%	100.0%	**50.0%**
						Western Europe	**35.09%**	**25.28%**	**41.71%**	**26.89%**	**Austria**	0.39%	1.46%	6.04%	**10.65%**	**Earthquake**	0	0	0.0	1	0.0%	0.0%	0.0%	**3.6%**
																Extreme temperature	2	0	0.0	1	2.0%	0.0%	0.0%	**3.6%**
																Flood	2	6142	356220.0	10	24.2%	85.6%	67.1%	**35.7%**
																Mass movement wet	32	5000	20785.0	2	63.6%	13.9%	0.8%	**7.1%**
																Storm	1	21	121857.1	14	10.1%	0.4%	32.1%	**50.0%**
											Belgium	4.85%	0.12%	2.51%	**12.17%**	**Earthquake**	0	0	100000.0	1	0.0%	0.0%	4.5%	**3.1%**
																Extreme temperature	392	0	0.0	3	96.5%	0.0%	0.0%	**9.4%**
																Flood	1	348	22095.5	12	0.5%	70.1%	12.0%	**37.5%**
																Storm	2	111	115311.	16	3.0%	29.9	83.5	**50.0**

								6			%	%	**%**
France	85.34%	83.31%	38.85%	**32.32%**	**Epidemic**	20	0	0.0	1	0.1%	0.0%	0.0%	**1.2%**
					Extreme temperature	1904	927	470181.8	11	97.5 %	0.2%	15.1 %	**12.9 %**
					Flood	4	2062	184278.3	30	0.6%	1.5%	16.2 %	**35.3 %**
					Mass movement wet	11	94	3596.7	3	0.2%	0.0%	0.0%	**3.5%**
					Storm	9	108505	634353.0	37	1.6%	98.1 %	68.7 %	**43.5 %**
					Wildfire	2	1423	0.0	3	0.0%	0.1%	0.0%	**3.5%**
Germany	1.02%	9.56%	38.96%	**21.29%**	**Earthquake**	1	838	31000.0	2	0.4%	0.4%	0.2%	**3.6%**
					Epidemic	0	600	0.0	1	0.0%	0.1%	0.0%	**1.8%**
					Extreme temperature	9	33	60000.0	5	16.1 %	0.0%	0.9%	**9.1%**
					Flood	3	33597	1017200.0	13	15.7 %	93.0 %	38.6 %	**23.6 %**
					Storm	5	890	606773.5	34	67.9 %	6.4%	60.3 %	**61.8 %**
Luxembourg	0.00%	0.00%	0.48%	**3.42%**	**Flood**	0	0	10000.0	1	0.0%	0.0%	2.4%	**11.1 %**
					Storm	0	0	51375.0	8	0.0%	0.0%	97.6 %	**88.9 %**
Netherlands	8.00%	5.40%	5.14%	**9.13%**	**Earthquake**	0	20	0.0	1	0.0%	0.0%	0.0%	**4.2%**
					Epidemic	13	200	0.0	1	0.6%	0.1%	0.0%	**4.2%**
					Extreme temperature	491	0	25000.0	4	97.6 %	0.0%	2.2%	**16.7 %**
					Flood	0	5000	203533.3	3	0.0%	5.7%	13.5 %	**12.5 %**
					Storm	2	16673	254006.7	15	1.7%	94.3 %	84.3 %	**62.5 %**
erl	0.31%	0.15%	8.03%	**03**	**Epidemic**	0	1	0.0	1	0.0%	0.0%	0.0%	**3.4%**

															Extreme temperature	0	0	0.0	3	0.0%	0.0%	0.0%	**10.3 %**
															Flood	2	1400	629625.0	4	9.1%	75.7 %	35.7 %	**13.8 %**
															Mass movement wet	13	445	298750.0	4	64.9 %	24.1 %	16.9 %	**13.8 %**
															Storm	1	1	196985.9	17	26.0 %	0.2%	47.4 %	**58.6 %**
Oceania	**0.31%**	**0.69%**	**2.59%**	**4.32%**	**Australia and New Zealand**	**19.48%**	**91.02%**	**95.31%**	**47.30%**	**Australia**	78.81%	96.25%	44.67%	**81.43%**	Drought	0	3500000	986500.0	2	0.0%	44.5 %	9.8%	**1.8%**
															Earthquake	0	5025	0.0	1	0.0%	0.0%	0.0%	**0.9%**
															Epidemic	0	6	0.0	1	0.0%	0.0%	0.0%	**0.9%**
															Extreme temperature	74	920557	0.0	5	51.8 %	29.2 %	0.0%	**4.4%**
															Flood	1	2516	145975.8	33	6.2%	0.5%	23.9 %	**28.9 %**
															Insect infestation	0	0	120000.0	1	0.0%	0.0%	0.6%	**0.9%**
															Mass movement wet	14	51	0.0	2	3.9%	0.0%	0.0%	**1.8%**
															Storm	1	71222	203399.1	56	9.1%	25.3 %	56.5 %	**49.1 %**
															Wildfire	16	4716	142130.8	13	29.0 %	0.4%	9.2%	**11.4 %**
										New Zealand	21.19%	3.75%	55.33%	**18.57%**	Earthquake	61	200616	8166666.7	3	94.8 %	98.2 %	98.2 %	**11.5 %**
															Epidemic	0	1	0.0	1	0.0%	0.0%	0.0%	**3.8%**
															Flood	0	647	30500.0	13	2.1%	1.4%	1.6%	**50.0 %**
															Storm	1	318	8062.5	8	3.1%	0.4%	0.3%	**30.8 %**
															Volcano	0	70	0.0	1	0.0%	0.0%	0.0%	**3.8%**
					lan esi	**38**	**6.7 8%**	**1.1 0%**	**80**	**Fiji**	3.8 4%	66	84	**33**	Earthquake	0	0	0.0	2	0.0%	0.0%	0.0%	**8.7%**

					Flood	4	1754	11535.3	7	19.8%	4.7%	26.0%	**30.4%**
					Storm	8	17961	16391.4	14	80.2%	95.3%	74.0%	**60.9%**
New Caledonia	0.06%	0.13%	7.72%	**2.91%**	**Epidemic**	0	437	0.0	1	0.0%	28.4%	0.0%	**33.3%**
					Storm	1	550	20000.0	2	100.0%	71.6%	100.0%	**66.7%**
Papua New Guinea	89.28%	60.43%	31.29%	**39.81%**	**Earthquake**	280	5117	625.0	8	73.6%	5.6%	3.1%	**19.5%**
					Epidemic	64	903	0.0	4	8.4%	0.5%	0.0%	**9.8%**
					Flood	1	35274	5716.0	8	0.1%	38.4%	28.2%	**19.5%**
					Mass movement dry	10	0	0.0	1	0.3%	0.0%	0.0%	**2.4%**
					Mass movement wet	44	872	0.0	7	10.1%	0.8%	0.0%	**17.1%**
					Storm	55	52420	375.0	4	7.2%	28.5%	0.9%	**9.8%**
					Volcano	1	23141	13750.0	8	0.3%	25.2%	67.8%	**19.5%**
					Wildfire	0	8000	0.0	1	0.0%	1.1%	0.0%	**2.4%**
Solomon Is	2.31%	9.62%	0.00%	**11.65%**	**Earthquake**	26	1755	0.0	2	65.8%	3.0%	0.0%	**16.7%**
					Flood	8	7672	0.0	3	29.1%	19.6%	0.0%	**25.0%**
					Storm	1	12946	0.0	7	5.1%	77.4%	0.0%	**58.3%**
Vanuatu	4.51%	8.16%	1.16%	**23.30%**	**Earthquake**	14	1888	0.0	8	72.7%	15.2%	0.0%	**33.3%**
					Flood	0	1976	0.0	2	0.0%	4.0%	0.0%	**8.3%**
					Storm	4	7037	600.0	10	27.3	70.8	100.	**41.7**

																				%	%	0%	**%**
																Volcano	0	2475	0.0	4	0.0%	10.0 %	0.0%	**16.7 %**
						Micronesia	**1.29%**	**0.24%**	**1.59%**	**6.08%**	**Guam**	5.00%	63.15%	99.93%	**38.89%**	**Earthquake**	0	71	120000.0	1	0.0%	0.3%	16.0 %	**14.3 %**
																Storm	1	4568	105166.7	6	100.0%	99.7 %	84.0 %	**85.7 %**
											Kiribati	0.00%	0.20%	0.00%	**5.56%**	**Flood**	0	85	0.0	1	100.0%	100.0%	100.0%	**100.0%**
											Marshall Is	10.00%	15.67%	0.00%	**16.67%**	**Epidemic**	6	218	0.0	1	100.0%	3.2%	0.0%	**33.3 %**
																Flood	0	600	0.0	1	0.0%	8.8%	0.0%	**33.3 %**
																Storm	0	6000	0.0	1	0.0%	88.0 %	0.0%	**33.3 %**
											Micronesia Fed States	80.00%	19.84%	0.07%	**27.78%**	**Flood**	0	0	0.0	1	0.0%	0.0%	0.0%	**20.0 %**
																Storm	12	2158	125.0	4	100.0%	100.0%	100.0%	**80.0 %**
											Northern Mariana Is	5.00%	1.15%	0.00%	**11.11%**	**Storm**	2	250	0.0	2	100.0%	100.0%	100.0%	**100.0%**
						Polyn esia	**5.85 %**	**1.96 %**	**2.01 %**	**11.82 %**	**ican Samo**	14.71 %	7.25 %	21.07 %	**11.43 %**	**Earthquake**	34	2500	0.0	1	85.0 %	9.8%	0.0%	**25.0 %**

																Flood	6	3	50000.0	1	15.0%	0.0%	25.0%	**25.0%**
																Storm	0	11530	75000.0	2	0.0%	90.2%	75.0%	**50.0%**
											Cook Is	9.93%	1.60%	0.00%	**17.14%**	**Epidemic**	7	1200	0.0	1	25.9%	21.2%	0.0%	**16.7%**
																Storm	4	891	0.0	5	74.1%	78.8%	0.0%	**83.3%**
											French Polynesia	5.15%	1.11%	1.16%	**8.57%**	**Mass movement wet**	7	256	0.0	2	92.9%	13.0%	0.0%	**66.7%**
																Storm	1	3411	11000.0	1	7.1%	87.0%	100.0%	**33.3%**
											Niue	0.74%	0.34%	4.21%	**8.57%**	**Epidemic**	1	297	0.0	1	50.0%	24.8%	0.0%	**33.3%**
																Storm	1	451	20000.0	2	50.0%	75.2%	100.0%	**66.7%**
											Samoa	63.97%	81.84%	66.32%	**17.14%**	**Earthquake**	143	5585	150000.0	1	82.2%	1.9%	23.8%	**16.7%**
																Flood	0	0	1500.0	1	0.0%	0.0%	0.2%	**16.7%**
																Storm	8	70750	119500.0	4	17.8%	98.1%	75.9%	**66.7%**
											Tokelau	0.00%	0.04%	0.25%	**5.71%**	**Storm**	0	64	1200.0	2	100.0%	100.0%	100.0%	**100.0%**
											Tonga	3.68%	7.57%	6.98%	**22.86%**	**Earthquake**	9	507	9500.0	1	90.0%	1.9%	14.3%	**12.5%**
																Storm	0	3739	8114.3	7	10.0%	98.1%	85.7%	**87.5%**

										Tuvalu	0.00%	0.24%	0.00%	**5.71%**	**Storm**	0	425	0.0	2	100.0%	100.0%	100.0%	**100.0%**
										Wallis	1.84%	0.01%	0.00%	**2.86%**	**Earthquake**	5	20	0.0	1	100.0%	100.0%	100.0%	**100.0%**

APPENDIX B

Probability of occurrence for each type of disaster in each country

Type of disaster	Country	Probablitity of ocuccerins	
Complex Disasters	Armenia	0.083333333	0.083333
	Bangladesh	0.083333333	0.166667
	Burundi	0.083333333	0.25
	Cambodia	0.083333333	0.333333
	Comoros	0.083333333	0.416667
	India	0.083333333	0.5
	Korea Dem P Rep	0.083333333	0.583333
	Nicaragua	0.083333333	0.666667
	Panama	0.083333333	0.75
	Soviet Union	0.083333333	0.833333
	Sudan	0.083333333	0.916667
	Togo	0.083333333	1
Complex Disasters Total		1	
Drought	Afghanistan	0.00974026	0.00974
	Albania	0.001623377	0.011364
	Algeria	0.003246753	0.01461
	Angola	0.00974026	0.024351
	Anguilla	0.001623377	0.025974
	Antigua and Barbuda	0.001623377	0.027597
	Argentina	0.003246753	0.030844
	Armenia	0.001623377	0.032468
	Australia	0.016233766	0.048701
	Azerbaijan	0.001623377	0.050325

	Bangladesh	0.011363636	0.061688
	Barbados	0.001623377	0.063312
	Belgium	0.001623377	0.064935
	Benin	0.003246753	0.068182
	Bolivia	0.016233766	0.084416
	Bosnia-Hercegovenia	0.003246753	0.087662
	Botswana	0.00974026	0.097403
	Brazil	0.025974026	0.123377
	Bulgaria	0.003246753	0.126623
	Burkina Faso	0.019480519	0.146104
	Burundi	0.00974026	0.155844
	Cambodia	0.008116883	0.163961
	Cameroon	0.006493506	0.170455
	Canada	0.008116883	0.178571
	Cape Verde Is	0.016233766	0.194805
	Central African Rep	0.001623377	0.196429
	Chad	0.01461039	0.211039
	Chile	0.003246753	0.214286
	China P Rep	0.053571429	0.267857
	Colombia	0.001623377	0.269481
	Comoros	0.001623377	0.271104
	Congo	0.001623377	0.272727
	Costa Rica	0.00487013	0.277597
	Cote d'Ivoire	0.001623377	0.279221
	Croatia	0.001623377	0.280844
	Cuba	0.00974026	0.290584
	Cyprus	0.003246753	0.293831
	Denmark	0.001623377	0.295455
	Djibouti	0.01461039	0.310065

	Dominican Rep	0.001623377	0.311688
	Ecuador	0.00487013	0.316558
	El Salvador	0.008116883	0.324675
	Eritrea	0.00487013	0.329545
	Ethiopia	0.022727273	0.352273
	Fiji	0.003246753	0.355519
	France	0.006493506	0.362013
	Gambia The	0.011363636	0.373377
	Georgia	0.001623377	0.375
	Ghana	0.00487013	0.37987
	Greece	0.001623377	0.381494
	Grenada	0.001623377	0.383117
	Guatemala	0.006493506	0.38961
	Guinea	0.003246753	0.392857
	Guinea Bissau	0.00974026	0.402597
	Guyana	0.00487013	0.407468
	Haiti	0.011363636	0.418831
	Honduras	0.01461039	0.433442
	Hong Kong (China)	0.011363636	0.444805
	Hungary	0.00487013	0.449675
	India	0.022727273	0.472403
	Indonesia	0.01461039	0.487013
	Iran Islam Rep	0.003246753	0.49026
	Iraq	0.003246753	0.493506
	Israel	0.001623377	0.49513
	Italy	0.003246753	0.498377
	Jamaica	0.00487013	0.503247
	Japan	0.001623377	0.50487
	Jordan	0.003246753	0.508117

	Kenya	0.019480519	0.527597
	Kiribati	0.001623377	0.529221
	Korea Rep	0.003246753	0.532468
	Kyrgyzstan	0.001623377	0.534091
	Lao P Dem Rep	0.008116883	0.542208
	Lesotho	0.00974026	0.551948
	Liberia	0.001623377	0.553571
	Lithuania	0.003246753	0.556818
	Macedonia FRY	0.001623377	0.558442
	Madagascar	0.00974026	0.568182
	Malawi	0.00974026	0.577922
	Malaysia	0.001623377	0.579545
	Mali	0.017857143	0.597403
	Mauritania	0.019480519	0.616883
	Mauritius	0.001623377	0.618506
	Mexico	0.011363636	0.62987
	Micronesia Fed States	0.001623377	0.631494
	Moldova Rep	0.003246753	0.63474
	Mongolia	0.001623377	0.636364
	Morocco	0.008116883	0.644481
	Mozambique	0.019480519	0.663961
	Namibia	0.00974026	0.673701
	Nepal	0.00974026	0.683442
	New Zealand	0.001623377	0.685065
	Nicaragua	0.006493506	0.691558
	Niger	0.021103896	0.712662
	Nigeria	0.001623377	0.714286
	Pakistan	0.001623377	0.715909
	Panama	0.001623377	0.717532

	Papua New Guinea	0.003246753	0.720779
	Paraguay	0.00974026	0.730519
	Peru	0.012987013	0.743506
	Philippines	0.012987013	0.756494
	Portugal	0.00487013	0.761364
	Puerto Rico	0.001623377	0.762987
	Romania	0.003246753	0.766234
	Russia	0.006493506	0.772727
	Rwanda	0.00974026	0.782468
	Sao Tome et Principe	0.001623377	0.784091
	Senegal	0.01461039	0.798701
	Solomon Is	0.003246753	0.801948
	Somalia	0.019480519	0.821429
	South Africa	0.012987013	0.834416
	Soviet Union	0.001623377	0.836039
	Spain	0.006493506	0.842532
	Sri Lanka	0.012987013	0.855519
	St Lucia	0.001623377	0.857143
	Sudan	0.012987013	0.87013
	Swaziland	0.008116883	0.878247
	Syrian Arab Rep	0.003246753	0.881494
	Tajikistan	0.003246753	0.88474
	Tanzania Uni Rep	0.016233766	0.900974
	Thailand	0.012987013	0.913961
	Timor-Leste	0.001623377	0.915584
	Togo	0.00487013	0.920455
	Trinidad and Tobago	0.001623377	0.922078
	Tunisia	0.003246753	0.925325
	Tuvalu	0.001623377	0.926948

	Uganda	0.01461039	0.941558
	United States	0.016233766	0.957792
	Uruguay	0.001623377	0.959416
	Uzbekistan	0.001623377	0.961039
	Venezuela	0.001623377	0.962662
	Viet Nam	0.008116883	0.970779
	Yemen Arab Rep	0.003246753	0.974026
	Yemen P Dem Rep	0.003246753	0.977273
	Yugoslavia	0.001623377	0.978896
	Zaire/Congo Dem Rep	0.003246753	0.982143
	Zambia	0.008116883	0.99026
	Zimbabwe	0.00974026	1
Drought Total		1	
Earthquake (seismic activity)	Afghanistan	0.024207012	0.024207
	Albania	0.005008347	0.029215
	Algeria	0.016694491	0.04591
	American Samoa	0.001669449	0.047579
	Argentina	0.004173623	0.051753
	Armenia	0.000834725	0.052588
	Australia	0.003338898	0.055927
	Austria	0.000834725	0.056761
	Azerbaijan	0.002504174	0.059265
	Azores	0.002504174	0.06177
	Bangladesh	0.005843072	0.067613
	Barbados	0.000834725	0.068447
	Belgium	0.001669449	0.070117
	Bhutan	0.001669449	0.071786
	Bolivia	0.002504174	0.07429
	Brazil	0.001669449	0.07596

	Bulgaria	0.004173623	0.080134
	Burundi	0.000834725	0.080968
	Canada	0.000834725	0.081803
	Chile	0.023372287	0.105175
	China P Rep	0.10851419	0.213689
	Colombia	0.019198664	0.232888
	Congo	0.000834725	0.233723
	Costa Rica	0.010851419	0.244574
	Croatia	0.000834725	0.245409
	Cuba	0.001669449	0.247078
	Cyprus	0.001669449	0.248748
	Dominica	0.000834725	0.249583
	Dominican Rep	0.001669449	0.251252
	Ecuador	0.013355593	0.264608
	Egypt	0.004173623	0.268781
	El Salvador	0.008347245	0.277129
	Ethiopia	0.005843072	0.282972
	Fiji	0.001669449	0.284641
	France	0.001669449	0.286311
	Georgia	0.003338898	0.289649
	Germany	0.001669449	0.291319
	Germany Fed Rep	0.000834725	0.292154
	Ghana	0.000834725	0.292988
	Greece	0.024207012	0.317195
	Guadeloupe	0.000834725	0.31803
	Guam	0.000834725	0.318865
	Guatemala	0.010851419	0.329716
	Guinea	0.000834725	0.330551
	Haiti	0.001669449	0.33222

	Honduras	0.004173623	0.336394
	Iceland	0.002504174	0.338898
	India	0.022537563	0.361436
	Indonesia	0.089315526	0.450751
	Iran Islam Rep	0.081803005	0.532554
	Iraq	0.000834725	0.533389
	Italy	0.025041736	0.558431
	Jamaica	0.000834725	0.559265
	Japan	0.047579299	0.606845
	Jordan	0.000834725	0.607679
	Kazakhstan	0.000834725	0.608514
	Kenya	0.001669449	0.610184
	Korea Dem P Rep	0.000834725	0.611018
	Kyrgyzstan	0.005843072	0.616861
	Lebanon	0.000834725	0.617696
	Libyan Arab Jamah	0.000834725	0.618531
	Malawi	0.002504174	0.621035
	Malaysia	0.000834725	0.62187
	Maldives	0.000834725	0.622705
	Martinique	0.000834725	0.623539
	Mexico	0.024207012	0.647746
	Mongolia	0.000834725	0.648581
	Morocco	0.002504174	0.651085
	Mozambique	0.000834725	0.65192
	Myanmar	0.005843072	0.657763
	Nepal	0.005008347	0.662771
	Netherlands	0.000834725	0.663606
	New Zealand	0.006677796	0.670284
	Nicaragua	0.007512521	0.677796

	Pakistan	0.020033389	0.69783
	Panama	0.003338898	0.701169
	Papua New Guinea	0.011686144	0.712855
	Peru	0.033388982	0.746244
	Philippines	0.020033389	0.766277
	Poland	0.000834725	0.767112
	Puerto Rico	0.000834725	0.767947
	Romania	0.010851419	0.778798
	Russia	0.00918197	0.78798
	Rwanda	0.001669449	0.789649
	Samoa	0.000834725	0.790484
	Serbia	0.000834725	0.791319
	Serbia Montenegro	0.000834725	0.792154
	Seychelles	0.000834725	0.792988
	Slovenia	0.001669449	0.794658
	Solomon Is	0.005843072	0.800501
	Somalia	0.000834725	0.801336
	South Africa	0.006677796	0.808013
	Soviet Union	0.021702838	0.829716
	Spain	0.002504174	0.83222
	Sri Lanka	0.000834725	0.833055
	St Lucia	0.000834725	0.83389
	Sudan	0.001669449	0.835559
	Taiwan (China)	0.00918197	0.844741
	Tajikistan	0.006677796	0.851419
	Tanzania Uni Rep	0.008347245	0.859766
	Thailand	0.003338898	0.863105
	Tonga	0.001669449	0.864775
	Trinidad and Tobago	0.000834725	0.865609

	Tunisia	0.000834725	0.866444
	Turkey	0.063439065	0.929883
	Turkmenistan	0.000834725	0.930718
	Uganda	0.004173623	0.934891
	United Kingdom	0.001669449	0.936561
	United States	0.033388982	0.96995
	Uzbekistan	0.001669449	0.971619
	Vanuatu	0.007512521	0.979132
	Venezuela	0.006677796	0.98581
	Wallis	0.000834725	0.986644
	Yemen	0.000834725	0.987479
	Yemen Arab Rep	0.000834725	0.988314
	Yugoslavia	0.00918197	0.997496
	Zaire/Congo Dem Rep	0.002504174	1
Earthquake (seismic activity) Total		1	
Epidemic	Afghanistan	0.0154202	0.01542
	Albania	0.00154202	0.016962
	Algeria	0.00154202	0.018504
	Angola	0.01387818	0.032382
	Anguilla	0.00385505	0.036237
	Argentina	0.00154202	0.037779
	Australia	0.00077101	0.038551
	Bahrain	0.00077101	0.039322
	Bangladesh	0.023130301	0.062452
	Belarus	0.00154202	0.063994
	Belgium	0.00077101	0.064765
	Benin	0.017733231	0.082498
	Bhutan	0.00154202	0.08404

	Bolivia	0.00925212	0.093292
	Bosnia-Hercegovenia	0.00077101	0.094063
	Botswana	0.00231303	0.096376
	Brazil	0.01233616	0.108712
	Burkina Faso	0.018504241	0.127217
	Burundi	0.01079414	0.138011
	Cambodia	0.00693909	0.14495
	Cameroon	0.01619121	0.161141
	Canada	0.00539707	0.166538
	Cape Verde Is	0.00154202	0.16808
	Central African Rep	0.00693909	0.175019
	Chad	0.0154202	0.190439
	Chile	0.00077101	0.19121
	China P Rep	0.0077101	0.198921
	Colombia	0.00154202	0.200463
	Comoros	0.00462606	0.205089
	Congo	0.01079414	0.215883
	Cook Is	0.00231303	0.218196
	Costa Rica	0.00077101	0.218967
	Cote d'Ivoire	0.01002313	0.22899
	Cuba	0.00154202	0.230532
	Cyprus	0.00154202	0.232074
	Djibouti	0.00385505	0.235929
	Dominican Rep	0.00539707	0.241326
	Ecuador	0.00925212	0.250578
	Egypt	0.00231303	0.252891
	El Salvador	0.00693909	0.25983
	Equatorial Guinea	0.00077101	0.260601
	Ethiopia	0.016962221	0.277564

	France	0.00154202	0.279106
	Gabon	0.00616808	0.285274
	Gambia The	0.00231303	0.287587
	Germany	0.00154202	0.289129
	Ghana	0.01233616	0.301465
	Guadeloupe	0.00077101	0.302236
	Guatemala	0.00539707	0.307633
	Guinea	0.00925212	0.316885
	Guinea Bissau	0.00616808	0.323053
	Haiti	0.00231303	0.325366
	Honduras	0.00616808	0.331534
	Hong Kong (China)	0.00077101	0.332305
	India	0.052428682	0.384734
	Indonesia	0.026985351	0.411719
	Iran Islam Rep	0.00231303	0.414032
	Iraq	0.00462606	0.418658
	Ireland	0.00154202	0.4202
	Israel	0.00077101	0.420971
	Italy	0.00154202	0.422513
	Jamaica	0.00385505	0.426369
	Japan	0.00231303	0.428682
	Jordan	0.00077101	0.429453
	Kazakhstan	0.00231303	0.431766
	Kenya	0.023901311	0.455667
	Kiribati	0.00077101	0.456438
	Korea Dem P Rep	0.00154202	0.45798
	Korea Rep	0.00308404	0.461064
	Kuwait	0.00077101	0.461835
	Kyrgyzstan	0.00231303	0.464148

	Lao P Dem Rep	0.00616808	0.470316
	Latvia	0.00077101	0.471087
	Lesotho	0.00231303	0.4734
	Liberia	0.00848111	0.481881
	Macau	0.00077101	0.482652
	Macedonia FRY	0.00077101	0.483423
	Madagascar	0.00385505	0.487278
	Malawi	0.01002313	0.497301
	Malaysia	0.01002313	0.507325
	Maldives	0.00154202	0.508867
	Mali	0.01387818	0.522745
	Marshall Is	0.00077101	0.523516
	Martinique	0.00077101	0.524287
	Mauritania	0.00462606	0.528913
	Mauritius	0.00154202	0.530455
	Mexico	0.00231303	0.532768
	Micronesia Fed States	0.00077101	0.533539
	Moldova Rep	0.00077101	0.53431
	Mongolia	0.00231303	0.536623
	Morocco	0.00077101	0.537394
	Mozambique	0.019275251	0.556669
	Myanmar	0.00231303	0.558982
	Namibia	0.00462606	0.563608
	Nepal	0.0154202	0.579029
	Netherlands	0.00077101	0.5798
	New Caledonia	0.00077101	0.580571
	New Zealand	0.00154202	0.582113
	Nicaragua	0.00848111	0.590594
	Niger	0.026985351	0.617579

	Nigeria	0.039321511	0.656901
	Niue	0.00077101	0.657672
	Pakistan	0.0077101	0.665382
	Palestine (West Bank)	0.00077101	0.666153
	Panama	0.00385505	0.670008
	Papua New Guinea	0.00539707	0.675405
	Paraguay	0.00616808	0.681573
	Peru	0.00925212	0.690825
	Philippines	0.01310717	0.703932
	Reunion	0.00077101	0.704703
	Romania	0.00231303	0.707016
	Russia	0.0077101	0.714726
	Rwanda	0.00925212	0.723978
	Sao Tome et Principe	0.00154202	0.72552
	Saudi Arabia	0.00231303	0.727833
	Senegal	0.00848111	0.736315
	Serbia Montenegro	0.00154202	0.737857
	Seychelles	0.00077101	0.738628
	Sierra Leone	0.01079414	0.749422
	Singapore	0.00231303	0.751735
	Somalia	0.020817271	0.772552
	South Africa	0.00539707	0.777949
	Soviet Union	0.00154202	0.779491
	Spain	0.00231303	0.781804
	Sri Lanka	0.00693909	0.788743
	Sudan	0.027756361	0.8165
	Swaziland	0.00231303	0.818813
	Sweden	0.00154202	0.820355
	Switzerland	0.00077101	0.821126

	Syrian Arab Rep	0.00154202	0.822668
	Taiwan (China)	0.00154202	0.82421
	Tajikistan	0.00385505	0.828065
	Tanzania Uni Rep	0.022359291	0.850424
	Thailand	0.00539707	0.855821
	Timor-Leste	0.00077101	0.856592
	Togo	0.0077101	0.864302
	Turkey	0.00616808	0.87047
	Uganda	0.025443331	0.895914
	Ukraine	0.00231303	0.898227
	United Kingdom	0.00308404	0.901311
	United States	0.00385505	0.905166
	Uzbekistan	0.00077101	0.905937
	Venezuela	0.00539707	0.911334
	Viet Nam	0.0077101	0.919044
	Yemen	0.00154202	0.920586
	Yugoslavia	0.00077101	0.921357
	Zaire/Congo Dem Rep	0.049344641	0.970702
	Zambia	0.01310717	0.983809
	Zimbabwe	0.01619121	1
Epidemic Total		1	
Extreme temperature	Afghanistan	0.013953488	0.013953
	Albania	0.006976744	0.02093
	Algeria	0.002325581	0.023256
	Argentina	0.018604651	0.04186
	Australia	0.011627907	0.053488
	Austria	0.009302326	0.062791
	Bangladesh	0.048837209	0.111628
	Belarus	0.004651163	0.116279

	Belgium	0.01627907	0.132558
	Belize	0.002325581	0.134884
	Bolivia	0.009302326	0.144186
	Bosnia-Hercegovenia	0.006976744	0.151163
	Brazil	0.018604651	0.169767
	Bulgaria	0.01627907	0.186047
	Canada	0.006976744	0.193023
	Canary Is	0.002325581	0.195349
	Chile	0.018604651	0.213953
	China P Rep	0.025581395	0.239535
	Croatia	0.009302326	0.248837
	Cyprus	0.006976744	0.255814
	Czech Rep	0.006976744	0.262791
	Czechoslovakia	0.006976744	0.269767
	Egypt	0.006976744	0.276744
	El Salvador	0.002325581	0.27907
	Estonia	0.002325581	0.281395
	France	0.030232558	0.311628
	Germany	0.018604651	0.330233
	Germany Fed Rep	0.002325581	0.332558
	Greece	0.013953488	0.346512
	Guatemala	0.006976744	0.353488
	Hong Kong (China)	0.002325581	0.355814
	Hungary	0.009302326	0.365116
	India	0.113953488	0.47907
	Iran Islam Rep	0.002325581	0.481395
	Israel	0.004651163	0.486047
	Italy	0.01627907	0.502326
	Japan	0.009302326	0.511628

	Jordan	0.004651163	0.516279
	Kazakhstan	0.004651163	0.52093
	Korea Rep	0.002325581	0.523256
	Kyrgyzstan	0.002325581	0.525581
	Latvia	0.006976744	0.532558
	Liberia	0.002325581	0.534884
	Lithuania	0.006976744	0.54186
	Luxembourg	0.002325581	0.544186
	Macedonia FRY	0.006976744	0.551163
	Mexico	0.039534884	0.590698
	Moldova Rep	0.002325581	0.593023
	Mongolia	0.002325581	0.595349
	Morocco	0.002325581	0.597674
	Nepal	0.013953488	0.611628
	Netherlands	0.009302326	0.62093
	New Zealand	0.002325581	0.623256
	Nigeria	0.004651163	0.627907
	Pakistan	0.034883721	0.662791
	Paraguay	0.006976744	0.669767
	Peru	0.018604651	0.688372
	Poland	0.025581395	0.713953
	Portugal	0.009302326	0.723256
	Romania	0.039534884	0.762791
	Russia	0.044186047	0.806977
	Serbia	0.009302326	0.816279
	Serbia Montenegro	0.004651163	0.82093
	Slovakia	0.009302326	0.830233
	Slovenia	0.002325581	0.832558
	South Africa	0.004651163	0.837209

	Spain	0.018604651	0.855814
	Sweden	0.002325581	0.85814
	Switzerland	0.009302326	0.867442
	Tajikistan	0.002325581	0.869767
	Turkey	0.01627907	0.886047
	Ukraine	0.009302326	0.895349
	United Kingdom	0.01627907	0.911628
	United States	0.076744186	0.988372
	Uruguay	0.009302326	0.997674
	Yugoslavia	0.002325581	1
Extreme temperature Total		1	
Flood	Afghanistan	0.016008004	0.016008
	Albania	0.002251126	0.018259
	Algeria	0.011505753	0.029765
	American Samoa	0.000250125	0.030015
	Angola	0.007003502	0.037019
	Anguilla	0.000250125	0.037269
	Argentina	0.011505753	0.048774
	Armenia	0.000750375	0.049525
	Australia	0.014507254	0.064032
	Austria	0.003751876	0.067784
	Azerbaijan	0.001750875	0.069535
	Bahamas	0.000250125	0.069785
	Bangladesh	0.02076038	0.090545
	Barbados	0.00050025	0.091046
	Belarus	0.000750375	0.091796
	Belgium	0.005502751	0.097299
	Belize	0.0010005	0.098299
	Benin	0.004252126	0.102551

	Bhutan	0.000750375	0.103302
	Bolivia	0.008504252	0.111806
	Bosnia-Hercegovenia	0.002001001	0.113807
	Botswana	0.002001001	0.115808
	Brazil	0.028764382	0.144572
	Bulgaria	0.003251626	0.147824
	Burkina Faso	0.003751876	0.151576
	Burundi	0.005002501	0.156578
	Cambodia	0.003751876	0.16033
	Cameroon	0.002501251	0.162831
	Canada	0.008754377	0.171586
	Canary Is	0.00050025	0.172086
	Cape Verde Is	0.000250125	0.172336
	Central African Rep	0.003501751	0.175838
	Chad	0.003751876	0.17959
	Chile	0.006503252	0.186093
	China P Rep	0.052776388	0.238869
	Colombia	0.016508254	0.255378
	Comoros	0.000250125	0.255628
	Congo	0.001750875	0.257379
	Costa Rica	0.006503252	0.263882
	Cote d'Ivoire	0.00150075	0.265383
	Croatia	0.00150075	0.266883
	Cuba	0.005252626	0.272136
	Czech Rep	0.003001501	0.275138
	Czechoslovakia	0.000250125	0.275388
	Djibouti	0.001750875	0.277139
	Dominican Rep	0.005002501	0.282141
	Ecuador	0.006753377	0.288894

	Egypt	0.003001501	0.291896
	El Salvador	0.003751876	0.295648
	Eritrea	0.00050025	0.296148
	Ethiopia	0.012506253	0.308654
	Fiji	0.002501251	0.311156
	Finland	0.000250125	0.311406
	France	0.010005003	0.321411
	French Guiana	0.000250125	0.321661
	Gabon	0.000250125	0.321911
	Gambia The	0.002001001	0.323912
	Georgia	0.002251126	0.326163
	Germany	0.003501751	0.329665
	Germany Fed Rep	0.001750875	0.331416
	Ghana	0.004002001	0.335418
	Greece	0.005002501	0.34042
	Grenada	0.000250125	0.34067
	Guadeloupe	0.000250125	0.34092
	Guatemala	0.005502751	0.346423
	Guinea	0.002501251	0.348924
	Guinea Bissau	0.0010005	0.349925
	Guyana	0.00150075	0.351426
	Haiti	0.011255628	0.362681
	Honduras	0.007253627	0.369935
	Hong Kong (China)	0.006253127	0.376188
	Hungary	0.003501751	0.37969
	Iceland	0.000250125	0.37994
	India	0.06078039	0.44072
	Indonesia	0.036268134	0.476988
	Iran Islam Rep	0.018009005	0.494997

	Iraq	0.002251126	0.497249
	Ireland	0.001250625	0.498499
	Israel	0.000750375	0.49925
	Italy	0.009254627	0.508504
	Jamaica	0.003251626	0.511756
	Japan	0.011505753	0.523262
	Jordan	0.00150075	0.524762
	Kazakhstan	0.002001001	0.526763
	Kenya	0.010255128	0.537019
	Kiribati	0.000250125	0.537269
	Korea Dem P Rep	0.005252626	0.542521
	Korea Rep	0.009004502	0.551526
	Kuwait	0.000250125	0.551776
	Kyrgyzstan	0.000750375	0.552526
	Lao P Dem Rep	0.005002501	0.557529
	Lebanon	0.000750375	0.558279
	Lesotho	0.001250625	0.55953
	Liberia	0.001250625	0.56078
	Libyan Arab Jamah	0.000250125	0.561031
	Lithuania	0.00050025	0.561531
	Luxembourg	0.00050025	0.562031
	Macedonia FRY	0.001750875	0.563782
	Madagascar	0.00150075	0.565283
	Malawi	0.007503752	0.572786
	Malaysia	0.009004502	0.581791
	Maldives	0.00050025	0.582291
	Mali	0.004752376	0.587044
	Marshall Is	0.000250125	0.587294
	Mauritania	0.003751876	0.591046

	Mexico	0.015007504	0.606053
	Micronesia Fed States	0.000250125	0.606303
	Moldova Rep	0.001750875	0.608054
	Mongolia	0.001750875	0.609805
	Montenegro	0.0010005	0.610805
	Morocco	0.007503752	0.618309
	Mozambique	0.007253627	0.625563
	Myanmar	0.004752376	0.630315
	Namibia	0.002751376	0.633067
	Nepal	0.009504752	0.642571
	Netherlands	0.0010005	0.643572
	New Zealand	0.008504252	0.652076
	Nicaragua	0.004252126	0.656328
	Niger	0.004252126	0.66058
	Nigeria	0.009754877	0.670335
	Norway	0.000750375	0.671086
	Pakistan	0.018009005	0.689095
	Palestine (West Bank)	0.00050025	0.689595
	Panama	0.008254127	0.697849
	Papua New Guinea	0.002501251	0.70035
	Paraguay	0.003751876	0.704102
	Peru	0.010755378	0.714857
	Philippines	0.030765383	0.745623
	Poland	0.003251626	0.748874
	Portugal	0.003251626	0.752126
	Puerto Rico	0.00150075	0.753627
	Romania	0.010505253	0.764132
	Russia	0.012006003	0.776138
	Rwanda	0.002501251	0.778639

	Samoa	0.000250125	0.778889
	Saudi Arabia	0.003001501	0.781891
	Senegal	0.004502251	0.786393
	Serbia	0.001250625	0.787644
	Serbia Montenegro	0.002251126	0.789895
	Seychelles	0.000250125	0.790145
	Sierra Leone	0.001750875	0.791896
	Slovakia	0.002751376	0.794647
	Slovenia	0.000250125	0.794897
	Solomon Is	0.000750375	0.795648
	Somalia	0.008254127	0.803902
	South Africa	0.007753877	0.811656
	Soviet Union	0.004252126	0.815908
	Spain	0.006503252	0.822411
	Sri Lanka	0.013256628	0.835668
	St Kitts and Nevis	0.000250125	0.835918
	St Lucia	0.000250125	0.836168
	St Vincent and The Grenadines	0.001250625	0.837419
	Sudan	0.007753877	0.845173
	Suriname	0.000750375	0.845923
	Swaziland	0.00050025	0.846423
	Sweden	0.00050025	0.846923
	Switzerland	0.002001001	0.848924
	Syrian Arab Rep	0.000750375	0.849675
	Taiwan (China)	0.001750875	0.851426
	Tajikistan	0.005502751	0.856928
	Tanzania Uni Rep	0.008504252	0.865433
	Thailand	0.016008004	0.881441

	Timor-Leste	0.001250625	0.882691
	Togo	0.002751376	0.885443
	Trinidad and Tobago	0.00050025	0.885943
	Tunisia	0.003751876	0.889695
	Turkey	0.009504752	0.8992
	Turkmenistan	0.000250125	0.89945
	Uganda	0.004002001	0.903452
	Ukraine	0.003251626	0.906703
	United Kingdom	0.006253127	0.912956
	United States	0.03951976	0.952476
	Uruguay	0.003001501	0.955478
	Uzbekistan	0.000250125	0.955728
	Vanuatu	0.00050025	0.956228
	Venezuela	0.007003502	0.963232
	Viet Nam	0.016758379	0.97999
	Yemen	0.005752876	0.985743
	Yemen Arab Rep	0.000750375	0.986493
	Yemen P Dem Rep	0.001250625	0.987744
	Yugoslavia	0.00150075	0.989245
	Zaire/Congo Dem Rep	0.004752376	0.993997
	Zambia	0.004002001	0.997999
	Zimbabwe	0.002001001	1
Flood Total		1	
Industrial Accident	Afghanistan	0.003825555	0.003826
	Albania	0.000765111	0.004591
	Algeria	0.000765111	0.005356
	Angola	0.000765111	0.006121
	Argentina	0.002295333	0.008416
	Armenia	0.000765111	0.009181

	Australia	0.001530222	0.010712
	Austria	0.000765111	0.011477
	Azerbaijan	0.000765111	0.012242
	Bahrain	0.000765111	0.013007
	Bangladesh	0.00841622	0.021423
	Belgium	0.026013772	0.047437
	Benin	0.000765111	0.048202
	Bolivia	0.002295333	0.050497
	Brazil	0.009946442	0.060444
	Bulgaria	0.000765111	0.061209
	Burkina Faso	0.002295333	0.063504
	Burundi	0.001530222	0.065034
	Canada	0.015302219	0.080337
	Chile	0.002295333	0.082632
	China P Rep	0.371078806	0.453711
	Colombia	0.010711553	0.464422
	Costa Rica	0.000765111	0.465187
	Cote d'Ivoire	0.000765111	0.465953
	Cuba	0.001530222	0.467483
	Czechoslovakia	0.003060444	0.470543
	Denmark	0.002295333	0.472839
	Djibouti	0.000765111	0.473604
	Ecuador	0.003825555	0.477429
	Egypt	0.004590666	0.48202
	El Salvador	0.001530222	0.48355
	Ethiopia	0.000765111	0.484315
	France	0.010711553	0.495027
	Germany	0.009946442	0.504973
	Germany Dem Rep	0.000765111	0.505738

	Germany Fed Rep	0.003825555	0.509564
	Ghana	0.003060444	0.512624
	Greece	0.002295333	0.51492
	Guatemala	0.000765111	0.515685
	Guinea	0.001530222	0.517215
	Guinea Bissau	0.000765111	0.51798
	Guyana	0.000765111	0.518745
	Haiti	0.000765111	0.51951
	Honduras	0.001530222	0.521041
	Hong Kong (China)	0.000765111	0.521806
	Hungary	0.002295333	0.524101
	India	0.070390207	0.594491
	Indonesia	0.012241775	0.606733
	Iran Islam Rep	0.006885998	0.613619
	Iraq	0.002295333	0.615914
	Ireland	0.000765111	0.616679
	Israel	0.001530222	0.61821
	Italy	0.003825555	0.622035
	Jamaica	0.001530222	0.623565
	Japan	0.009946442	0.633512
	Jordan	0.000765111	0.634277
	Kazakhstan	0.003060444	0.637337
	Kenya	0.003825555	0.641163
	Korea Dem P Rep	0.001530222	0.642693
	Korea Rep	0.00841622	0.651109
	Kyrgyzstan	0.000765111	0.651875
	Lebanon	0.000765111	0.65264
	Libyan Arab Jamah	0.000765111	0.653405
	Malaysia	0.002295333	0.6557

	Mexico	0.026778883	0.682479
	Mongolia	0.000765111	0.683244
	Morocco	0.002295333	0.685539
	Mozambique	0.002295333	0.687835
	Myanmar	0.002295333	0.69013
	Netherlands	0.003060444	0.693191
	New Zealand	0.003060444	0.696251
	Nicaragua	0.001530222	0.697781
	Niger	0.000765111	0.698546
	Nigeria	0.022188217	0.720735
	Norway	0.001530222	0.722265
	Pakistan	0.01606733	0.738332
	Palestine (West Bank)	0.000765111	0.739097
	Papua New Guinea	0.000765111	0.739862
	Peru	0.003060444	0.742923
	Philippines	0.010711553	0.753634
	Poland	0.004590666	0.758225
	Puerto Rico	0.001530222	0.759755
	Romania	0.004590666	0.764346
	Russia	0.02448355	0.788829
	Rwanda	0.001530222	0.79036
	Saudi Arabia	0.001530222	0.79189
	Senegal	0.001530222	0.79342
	Serbia Montenegro	0.001530222	0.79495
	Sierra Leone	0.003825555	0.798776
	Singapore	0.000765111	0.799541
	Slovakia	0.001530222	0.801071
	Slovenia	0.000765111	0.801836
	South Africa	0.013006886	0.814843

	Soviet Union	0.00841622	0.823259
	Spain	0.009946442	0.833206
	Sri Lanka	0.000765111	0.833971
	Sudan	0.000765111	0.834736
	Sweden	0.000765111	0.835501
	Switzerland	0.002295333	0.837796
	Syrian Arab Rep	0.001530222	0.839327
	Taiwan (China)	0.006120888	0.845448
	Tajikistan	0.000765111	0.846213
	Tanzania Uni Rep	0.001530222	0.847743
	Thailand	0.012241775	0.859985
	Trinidad and Tobago	0.000765111	0.86075
	Tunisia	0.000765111	0.861515
	Turkey	0.016832441	0.878347
	Ukraine	0.017597552	0.895945
	United Arab Emirates	0.001530222	0.897475
	United Kingdom	0.012241775	0.909717
	United States	0.05661821	0.966335
	Venezuela	0.003825555	0.970161
	Viet Nam	0.010711553	0.980872
	Yemen	0.001530222	0.982402
	Yugoslavia	0.003060444	0.985463
	Zaire/Congo Dem Rep	0.009946442	0.995409
	Zambia	0.003825555	0.999235
	Zimbabwe	0.000765111	1
Industrial Accident Total		1	
Insect infestation	Afghanistan	0.011764706	0.011765
	Algeria	0.023529412	0.035294
	Australia	0.023529412	0.058824

	Botswana	0.011764706	0.070588
	Brazil	0.011764706	0.082353
	Burkina Faso	0.035294118	0.117647
	Cameroon	0.023529412	0.141176
	Cape Verde Is	0.023529412	0.164706
	Chad	0.058823529	0.223529
	China P Rep	0.011764706	0.235294
	Colombia	0.011764706	0.247059
	Eritrea	0.011764706	0.258824
	Ethiopia	0.047058824	0.305882
	Gambia The	0.047058824	0.352941
	Guinea Bissau	0.035294118	0.388235
	India	0.011764706	0.4
	Jordan	0.011764706	0.411765
	Liberia	0.011764706	0.423529
	Libyan Arab Jamah	0.011764706	0.435294
	Madagascar	0.011764706	0.447059
	Mali	0.058823529	0.505882
	Mauritania	0.047058824	0.552941
	Morocco	0.047058824	0.6
	Mozambique	0.011764706	0.611765
	Niger	0.070588235	0.682353
	Nigeria	0.023529412	0.705882
	Pakistan	0.011764706	0.717647
	Peru	0.011764706	0.729412
	Philippines	0.023529412	0.752941
	Russia	0.011764706	0.764706
	Senegal	0.058823529	0.823529
	Sudan	0.058823529	0.882353

	Tajikistan	0.011764706	0.894118
	Tanzania Uni Rep	0.023529412	0.917647
	Tunisia	0.023529412	0.941176
	Viet Nam	0.011764706	0.952941
	Yemen Arab Rep	0.023529412	0.976471
	Zambia	0.023529412	1
Insect infestation Total		1	
Mass movement dry	Afghanistan	0.018867925	0.018868
	Canada	0.150943396	0.169811
	China P Rep	0.113207547	0.283019
	Colombia	0.056603774	0.339623
	Ecuador	0.018867925	0.358491
	Egypt	0.037735849	0.396226
	Ethiopia	0.018867925	0.415094
	France	0.056603774	0.471698
	Guatemala	0.037735849	0.509434
	Honduras	0.018867925	0.528302
	India	0.018867925	0.54717
	Indonesia	0.018867925	0.566038
	Jamaica	0.018867925	0.584906
	Lebanon	0.018867925	0.603774
	Liberia	0.018867925	0.622642
	Malaysia	0.018867925	0.641509
	Morocco	0.018867925	0.660377
	Nepal	0.018867925	0.679245
	Pakistan	0.018867925	0.698113
	Papua New Guinea	0.037735849	0.735849
	Peru	0.037735849	0.773585
	Philippines	0.056603774	0.830189

	Russia	0.037735849	0.867925
	Soviet Union	0.075471698	0.943396
	Tajikistan	0.018867925	0.962264
	Turkey	0.018867925	0.981132
	Uzbekistan	0.018867925	1
Mass movement dry Total		1	
Mass movement wet	Afghanistan	0.020134228	0.020134
	Albania	0.001677852	0.021812
	Algeria	0.001677852	0.02349
	Angola	0.001677852	0.025168
	Argentina	0.005033557	0.030201
	Australia	0.003355705	0.033557
	Austria	0.013422819	0.04698
	Azerbaijan	0.001677852	0.048658
	Azores	0.001677852	0.050336
	Bangladesh	0.005033557	0.055369
	Bolivia	0.010067114	0.065436
	Bosnia-Hercegovenia	0.001677852	0.067114
	Brazil	0.038590604	0.105705
	Bulgaria	0.001677852	0.107383
	Cameroon	0.001677852	0.10906
	Chile	0.006711409	0.115772
	China P Rep	0.095637584	0.211409
	Colombia	0.065436242	0.276846
	Congo	0.001677852	0.278523
	Costa Rica	0.001677852	0.280201
	Cote d'Ivoire	0.001677852	0.281879
	Czechoslovakia	0.003355705	0.285235
	Ecuador	0.020134228	0.305369

	El Salvador	0.003355705	0.308725
	Ethiopia	0.003355705	0.312081
	France	0.010067114	0.322148
	French Polynesia	0.005033557	0.327181
	Germany	0.001677852	0.328859
	Guatemala	0.013422819	0.342282
	Guyana	0.001677852	0.34396
	Haiti	0.003355705	0.347315
	Honduras	0.001677852	0.348993
	Hong Kong (China)	0.010067114	0.35906
	Iceland	0.006711409	0.365772
	India	0.070469799	0.436242
	Indonesia	0.073825503	0.510067
	Iran Islam Rep	0.006711409	0.516779
	Israel	0.001677852	0.518456
	Italy	0.025167785	0.543624
	Jamaica	0.001677852	0.545302
	Japan	0.036912752	0.582215
	Kazakhstan	0.001677852	0.583893
	Kenya	0.006711409	0.590604
	Korea Rep	0.015100671	0.605705
	Kyrgyzstan	0.013422819	0.619128
	Malaysia	0.006711409	0.625839
	Mexico	0.020134228	0.645973
	Morocco	0.001677852	0.647651
	Mozambique	0.001677852	0.649329
	Myanmar	0.005033557	0.654362
	Nepal	0.030201342	0.684564
	New Zealand	0.001677852	0.686242

	Nicaragua	0.001677852	0.687919
	Nigeria	0.005033557	0.692953
	Norway	0.001677852	0.694631
	Pakistan	0.031879195	0.72651
	Papua New Guinea	0.016778523	0.743289
	Peru	0.052013423	0.795302
	Philippines	0.048657718	0.84396
	Puerto Rico	0.003355705	0.847315
	Romania	0.001677852	0.848993
	Russia	0.011744966	0.860738
	Rwanda	0.005033557	0.865772
	Sierra Leone	0.001677852	0.86745
	South Africa	0.001677852	0.869128
	Soviet Union	0.010067114	0.879195
	Spain	0.001677852	0.880872
	Sri Lanka	0.005033557	0.885906
	St Lucia	0.001677852	0.887584
	Sweden	0.001677852	0.889262
	Switzerland	0.016778523	0.90604
	Syrian Arab Rep	0.001677852	0.907718
	Taiwan (China)	0.001677852	0.909396
	Tajikistan	0.018456376	0.927852
	Tanzania Uni Rep	0.001677852	0.92953
	Thailand	0.005033557	0.934564
	Trinidad and Tobago	0.001677852	0.936242
	Turkey	0.018456376	0.954698
	Uganda	0.005033557	0.959732
	United Kingdom	0.001677852	0.961409
	United States	0.006711409	0.968121

	Uzbekistan	0.001677852	0.969799
	Vanuatu	0.001677852	0.971477
	Venezuela	0.006711409	0.978188
	Viet Nam	0.010067114	0.988255
	Yemen	0.003355705	0.991611
	Zaire/Congo Dem Rep	0.006711409	0.998322
	Zambia	0.001677852	1
Mass movement wet Total		1	
Miscellaneous accident	Afghanistan	0.007240547	0.007241
	Albania	0.000804505	0.008045
	Algeria	0.005631537	0.013677
	Angola	0.003218021	0.016895
	Argentina	0.004827031	0.021722
	Armenia	0.00160901	0.023331
	Australia	0.006436042	0.029767
	Austria	0.000804505	0.030571
	Bangladesh	0.012067578	0.042639
	Barbados	0.000804505	0.043443
	Belarus	0.00160901	0.045052
	Belgium	0.01689461	0.061947
	Belize	0.000804505	0.062751
	Benin	0.000804505	0.063556
	Brazil	0.01850362	0.08206
	Burkina Faso	0.000804505	0.082864
	Cambodia	0.004022526	0.086887
	Cameroon	0.00160901	0.088496
	Canada	0.013676589	0.102172
	Chile	0.004827031	0.106999
	China P Rep	0.094127112	0.201126

	Colombia	0.008045052	0.209171
	Congo	0.000804505	0.209976
	Cook Is	0.000804505	0.21078
	Costa Rica	0.00160901	0.212389
	Cote d'Ivoire	0.00160901	0.213998
	Cuba	0.000804505	0.214803
	Cyprus	0.00160901	0.216412
	Czechoslovakia	0.00160901	0.218021
	Denmark	0.00160901	0.21963
	Dominican Rep	0.00160901	0.221239
	Ecuador	0.003218021	0.224457
	Egypt	0.020112631	0.24457
	El Salvador	0.003218021	0.247788
	Equatorial Guinea	0.008849558	0.256637
	Estonia	0.00160901	0.258246
	Ethiopia	0.005631537	0.263878
	Finland	0.000804505	0.264682
	France	0.017699115	0.282381
	Gambia The	0.00160901	0.28399
	Georgia	0.000804505	0.284795
	Germany	0.004022526	0.288817
	Germany Fed Rep	0.000804505	0.289622
	Ghana	0.003218021	0.29284
	Greece	0.002413516	0.295253
	Grenada	0.000804505	0.296058
	Guatemala	0.004022526	0.30008
	Guinea	0.000804505	0.300885
	Guinea Bissau	0.002413516	0.303298
	Guyana	0.003218021	0.306516

	Haiti	0.010458568	0.316975
	Honduras	0.004022526	0.320998
	Hong Kong (China)	0.005631537	0.326629
	India	0.08769107	0.41432
	Indonesia	0.020917136	0.435237
	Iran Islam Rep	0.012872084	0.448109
	Iraq	0.005631537	0.453741
	Ireland	0.000804505	0.454545
	Israel	0.00160901	0.456154
	Italy	0.010458568	0.466613
	Jamaica	0.000804505	0.467418
	Japan	0.014481094	0.481899
	Jordan	0.000804505	0.482703
	Kazakhstan	0.004827031	0.48753
	Kenya	0.016090105	0.50362
	Korea Dem P Rep	0.002413516	0.506034
	Korea Rep	0.012067578	0.518101
	Kuwait	0.000804505	0.518906
	Kyrgyzstan	0.00160901	0.520515
	Lao P Dem Rep	0.000804505	0.521319
	Lebanon	0.00160901	0.522928
	Liberia	0.000804505	0.523733
	Libyan Arab Jamah	0.002413516	0.526146
	Lithuania	0.000804505	0.526951
	Macau	0.000804505	0.527755
	Madagascar	0.00160901	0.529364
	Malawi	0.000804505	0.530169
	Malaysia	0.005631537	0.5358
	Mali	0.002413516	0.538214

	Mexico	0.012067578	0.550282
	Morocco	0.006436042	0.556718
	Mozambique	0.000804505	0.557522
	Myanmar	0.01850362	0.576026
	Nepal	0.004022526	0.580048
	Netherlands	0.004022526	0.584071
	New Zealand	0.000804505	0.584875
	Nicaragua	0.00160901	0.586484
	Niger	0.00160901	0.588093
	Nigeria	0.020112631	0.608206
	Pakistan	0.020917136	0.629123
	Palau	0.000804505	0.629928
	Palestine (West Bank)	0.000804505	0.630732
	Panama	0.004827031	0.635559
	Paraguay	0.000804505	0.636364
	Peru	0.008045052	0.644409
	Philippines	0.080450523	0.724859
	Poland	0.004022526	0.728882
	Portugal	0.002413516	0.731295
	Puerto Rico	0.00160901	0.732904
	Romania	0.00160901	0.734513
	Russia	0.037811746	0.772325
	Saudi Arabia	0.015285599	0.787611
	Senegal	0.002413516	0.790024
	Serbia Montenegro	0.000804505	0.790829
	Sierra Leone	0.000804505	0.791633
	Singapore	0.00160901	0.793242
	Slovakia	0.000804505	0.794047
	Somalia	0.004022526	0.798069

	South Africa	0.010458568	0.808528
	Soviet Union	0.006436042	0.814964
	Spain	0.008045052	0.823009
	Sri Lanka	0.00160901	0.824618
	Sudan	0.006436042	0.831054
	Sweden	0.000804505	0.831858
	Switzerland	0.004022526	0.835881
	Syrian Arab Rep	0.000804505	0.836685
	Taiwan (China)	0.007240547	0.843926
	Tajikistan	0.000804505	0.84473
	Tanzania Uni Rep	0.005631537	0.850362
	Thailand	0.012067578	0.86243
	Trinidad and Tobago	0.00160901	0.864039
	Tunisia	0.000804505	0.864843
	Turkey	0.010458568	0.875302
	Turkmenistan	0.000804505	0.876106
	Tuvalu	0.000804505	0.876911
	Uganda	0.010458568	0.887369
	Ukraine	0.005631537	0.893001
	United Arab Emirates	0.003218021	0.896219
	United Kingdom	0.010458568	0.906677
	United States	0.065969429	0.972647
	Uruguay	0.000804505	0.973451
	Uzbekistan	0.002413516	0.975865
	Venezuela	0.005631537	0.981496
	Viet Nam	0.004827031	0.986323
	Yemen	0.004022526	0.990346
	Yemen P Dem Rep	0.000804505	0.99115
	Yugoslavia	0.000804505	0.991955

	Zaire/Congo Dem Rep	0.004022526	0.995977
	Zambia	0.00160901	0.997586
	Zimbabwe	0.002413516	1
Miscellaneous accident Total		1	
Storm	Afghanistan	0.001441338	0.001441
	Albania	0.000576535	0.002018
	Algeria	0.00115307	0.003171
	American Samoa	0.00115307	0.004324
	Anguilla	0.001729605	0.006054
	Antigua and Barbuda	0.003170943	0.009225
	Argentina	0.004900548	0.014125
	Australia	0.028250216	0.042375
	Austria	0.004900548	0.047276
	Azores	0.000576535	0.047852
	Bahamas	0.006053618	0.053906
	Bangladesh	0.046411069	0.100317
	Barbados	0.002017873	0.102335
	Belarus	0.000576535	0.102912
	Belgium	0.00691842	0.10983
	Belize	0.004035745	0.113866
	Benin	0.000288268	0.114154
	Bermuda	0.001729605	0.115884
	Bhutan	0.000576535	0.11646
	Bolivia	0.000576535	0.117037
	Bosnia-Hercegovenia	0.000576535	0.117613
	Botswana	0.000288268	0.117901
	Brazil	0.004900548	0.122802
	Bulgaria	0.001441338	0.124243
	Burundi	0.001729605	0.125973

	Cambodia	0.000864803	0.126838
	Canada	0.0115307	0.138368
	Canary Is	0.000864803	0.139233
	Cape Verde Is	0.000576535	0.13981
	Cayman Islands	0.002017873	0.141828
	Central African Rep	0.001441338	0.143269
	Chad	0.000864803	0.144134
	Chile	0.003747478	0.147881
	China P Rep	0.062265783	0.210147
	Colombia	0.002017873	0.212165
	Comoros	0.001729605	0.213894
	Cook Is	0.003170943	0.217065
	Costa Rica	0.002594408	0.21966
	Croatia	0.000288268	0.219948
	Cuba	0.010954165	0.230902
	Cyprus	0.00115307	0.232055
	Czech Rep	0.001729605	0.233785
	Czechoslovakia	0.000864803	0.23465
	Denmark	0.003747478	0.238397
	Djibouti	0.000288268	0.238686
	Dominica	0.003747478	0.242433
	Dominican Rep	0.00807149	0.250504
	Egypt	0.001441338	0.251946
	El Salvador	0.004035745	0.255982
	Eritrea	0.000288268	0.25627
	Estonia	0.000288268	0.256558
	Fiji	0.009801095	0.266359
	Finland	0.000576535	0.266936
	France	0.014701643	0.281637

	French Polynesia	0.00115307	0.28279
	Gabon	0.000576535	0.283367
	Gambia The	0.00115307	0.28452
	Georgia	0.000288268	0.284808
	Germany	0.010089363	0.294898
	Germany Dem Rep	0.000864803	0.295762
	Germany Fed Rep	0.002882675	0.298645
	Greece	0.00230614	0.300951
	Grenada	0.001729605	0.302681
	Guadeloupe	0.00345921	0.30614
	Guam	0.002594408	0.308735
	Guatemala	0.00345921	0.312194
	Guinea	0.000288268	0.312482
	Guinea Bissau	0.000576535	0.313059
	Haiti	0.010665898	0.323724
	Honduras	0.006053618	0.329778
	Hong Kong (China)	0.017872586	0.347651
	Hungary	0.001441338	0.349092
	India	0.045257999	0.39435
	Indonesia	0.002882675	0.397233
	Iran Islam Rep	0.00345921	0.400692
	Ireland	0.004035745	0.404728
	Israel	0.000576535	0.405304
	Italy	0.005188815	0.410493
	Jamaica	0.00807149	0.418564
	Japan	0.040933987	0.459498
	Jordan	0.000864803	0.460363
	Kazakhstan	0.000288268	0.460651
	Kenya	0.000288268	0.46094

	Kiribati	0.000288268	0.461228
	Korea Dem P Rep	0.002017873	0.463246
	Korea Rep	0.013836841	0.477083
	Kyrgyzstan	0.000288268	0.477371
	Lao P Dem Rep	0.001441338	0.478812
	Latvia	0.000864803	0.479677
	Lebanon	0.000576535	0.480254
	Lesotho	0.001729605	0.481983
	Liberia	0.000576535	0.48256
	Lithuania	0.000864803	0.483425
	Luxembourg	0.00230614	0.485731
	Macau	0.00115307	0.486884
	Macedonia FRY	0.000288268	0.487172
	Madagascar	0.012972038	0.500144
	Malawi	0.000288268	0.500432
	Malaysia	0.002017873	0.50245
	Maldives	0.000288268	0.502739
	Marshall Is	0.000288268	0.503027
	Martinique	0.004035745	0.507063
	Mauritania	0.000576535	0.507639
	Mauritius	0.005188815	0.512828
	Mexico	0.024214471	0.537042
	Micronesia Fed States	0.001441338	0.538484
	Moldova Rep	0.000576535	0.53906
	Mongolia	0.002594408	0.541655
	Montserrat	0.00115307	0.542808
	Morocco	0.000576535	0.543384
	Mozambique	0.005477083	0.548861
	Myanmar	0.004900548	0.553762

	Nepal	0.001729605	0.555491
	Netherlands	0.00576535	0.561257
	Netherlands Antilles	0.00115307	0.56241
	New Caledonia	0.00461228	0.567022
	New Zealand	0.002882675	0.569905
	Nicaragua	0.00576535	0.57567
	Niger	0.000288268	0.575958
	Nigeria	0.00115307	0.577112
	Niue	0.001441338	0.578553
	Northern Mariana Is	0.000576535	0.579129
	Norway	0.002017873	0.581147
	Oman	0.00230614	0.583453
	Pakistan	0.006630153	0.590084
	Panama	0.00115307	0.591237
	Papua New Guinea	0.001441338	0.592678
	Paraguay	0.001441338	0.594119
	Peru	0.00115307	0.595272
	Philippines	0.085615451	0.680888
	Poland	0.003747478	0.684635
	Portugal	0.001441338	0.686077
	Puerto Rico	0.005188815	0.691265
	Reunion	0.002594408	0.69386
	Romania	0.002882675	0.696743
	Russia	0.00576535	0.702508
	Samoa	0.002594408	0.705102
	Saudi Arabia	0.000288268	0.705391
	Senegal	0.000864803	0.706255
	Serbia Montenegro	0.000288268	0.706544
	Seychelles	0.000288268	0.706832

	Sierra Leone	0.000864803	0.707697
	Slovakia	0.000288268	0.707985
	Slovenia	0.000576535	0.708562
	Solomon Is	0.004324013	0.712886
	Somalia	0.000288268	0.713174
	South Africa	0.00691842	0.720092
	Soviet Union	0.001441338	0.721534
	Spain	0.005477083	0.727011
	Sri Lanka	0.002017873	0.729029
	St Helena	0.000288268	0.729317
	St Kitts and Nevis	0.00230614	0.731623
	St Lucia	0.004035745	0.735659
	St Vincent and The Grenadines	0.002594408	0.738253
	Sudan	0.000576535	0.73883
	Swaziland	0.000864803	0.739694
	Sweden	0.001729605	0.741424
	Switzerland	0.007783223	0.749207
	Syrian Arab Rep	0.000576535	0.749784
	Taiwan (China)	0.019313923	0.769098
	Tajikistan	0.000576535	0.769674
	Tanzania Uni Rep	0.00115307	0.770827
	Thailand	0.00922456	0.780052
	Timor-Leste	0.000288268	0.78034
	Togo	0.000288268	0.780628
	Tokelau	0.001729605	0.782358
	Tonga	0.00345921	0.785817
	Trinidad and Tobago	0.002017873	0.787835
	Turkey	0.002594408	0.79043

	Turks and Caicos Is	0.001729605	0.792159
	Tuvalu	0.001441338	0.7936
	Uganda	0.00115307	0.794754
	Ukraine	0.002017873	0.796771
	United Kingdom	0.010089363	0.806861
	United States	0.151916979	0.958778
	Uruguay	0.001729605	0.960507
	Vanuatu	0.007206688	0.967714
	Venezuela	0.00115307	0.968867
	Viet Nam	0.025079274	0.993946
	Virgin Is (UK)	0.000576535	0.994523
	Virgin Is (US)	0.001729605	0.996253
	Wallis and Futuna Is	0.000864803	0.997117
	Yemen	0.000576535	0.997694
	Zaire/Congo Dem Rep	0.001441338	0.999135
	Zimbabwe	0.000864803	1
Storm Total		1	
Transport Accident	Afghanistan	0.005769627	0.00577
	Albania	0.000618174	0.006388
	Algeria	0.007212034	0.0136
	Angola	0.007830208	0.02143
	Anguilla	0.000206058	0.021636
	Argentina	0.004945395	0.026581
	Armenia	0.000412116	0.026994
	Australia	0.00432722	0.031321
	Austria	0.001236349	0.032557
	Azerbaijan	0.002060581	0.034618
	Azores	0.000618174	0.035236
	Bahamas	0.000618174	0.035854

	Bahrain	0.000618174	0.036472
	Bangladesh	0.030702658	0.067175
	Belarus	0.000206058	0.067381
	Belgium	0.005975685	0.073357
	Belize	0.000206058	0.073563
	Benin	0.001648465	0.075211
	Bermuda	0.000412116	0.075623
	Bolivia	0.006593859	0.082217
	Bosnia-Hercegovenia	0.000618174	0.082835
	Brazil	0.021636101	0.104471
	Bulgaria	0.001236349	0.105708
	Burkina Faso	0.002266639	0.107974
	Burundi	0.001854523	0.109829
	Cambodia	0.001030291	0.110859
	Cameroon	0.007418092	0.118277
	Canada	0.010302905	0.12858
	Canary Is	0.001854523	0.130435
	Cape Verde Is	0.000412116	0.130847
	Central African Rep	0.003502988	0.13435
	Chad	0.000618174	0.134968
	Chile	0.002678755	0.137647
	China P Rep	0.052750876	0.190398
	Colombia	0.010302905	0.200701
	Comoros	0.002678755	0.203379
	Congo	0.003090872	0.20647
	Costa Rica	0.000412116	0.206882
	Cote d'Ivoire	0.003709046	0.210591
	Croatia	0.000824232	0.211416
	Cuba	0.004533278	0.215949

	Cyprus	0.000206058	0.216155
	Czech Rep	0.000618174	0.216773
	Czechoslovakia	0.000618174	0.217391
	Denmark	0.000412116	0.217803
	Djibouti	0.000824232	0.218628
	Dominica	0.000206058	0.218834
	Dominican Rep	0.002472697	0.221306
	Ecuador	0.004739336	0.226046
	Egypt	0.026375438	0.252421
	El Salvador	0.001236349	0.253658
	Equatorial Guinea	0.000824232	0.254482
	Eritrea	0.000824232	0.255306
	Estonia	0.000206058	0.255512
	Ethiopia	0.004945395	0.260457
	Fiji	0.000206058	0.260664
	Finland	0.000618174	0.261282
	France	0.010096847	0.271379
	French Polynesia	0.000206058	0.271585
	Gabon	0.001854523	0.273439
	Gambia The	0.001030291	0.274469
	Georgia	0.001648465	0.276118
	Germany	0.005563569	0.281681
	Germany Dem Rep	0.001236349	0.282918
	Germany Fed Rep	0.002678755	0.285597
	Ghana	0.003709046	0.289306
	Greece	0.00432722	0.293633
	Guadeloupe	0.000412116	0.294045
	Guam	0.000206058	0.294251
	Guatemala	0.005357511	0.299608

	Guinea	0.004945395	0.304554
	Guinea Bissau	0.001236349	0.30579
	Haiti	0.006387801	0.312178
	Honduras	0.001854523	0.314033
	Hong Kong (China)	0.001236349	0.315269
	Hungary	0.001648465	0.316917
	India	0.093550381	0.410468
	Indonesia	0.032557181	0.443025
	Iran Islam Rep	0.024314857	0.46734
	Iraq	0.002884814	0.470225
	Ireland	0.000824232	0.471049
	Israel	0.001236349	0.472285
	Italy	0.009272615	0.481558
	Jamaica	0.000206058	0.481764
	Japan	0.007005976	0.48877
	Jordan	0.001442407	0.490212
	Kazakhstan	0.000412116	0.490624
	Kenya	0.011745312	0.50237
	Korea Dem P Rep	0.001236349	0.503606
	Korea Rep	0.006387801	0.509994
	Kyrgyzstan	0.001030291	0.511024
	Lao P Dem Rep	0.000824232	0.511848
	Lebanon	0.000824232	0.512673
	Lesotho	0.000206058	0.512879
	Liberia	0.000412116	0.513291
	Libyan Arab Jamah	0.002060581	0.515351
	Lithuania	0.000206058	0.515557
	Luxembourg	0.000206058	0.515763
	Macau	0.000206058	0.51597

	Macedonia FRY	0.000824232	0.516794
	Madagascar	0.001442407	0.518236
	Malawi	0.002884814	0.521121
	Malaysia	0.002884814	0.524006
	Maldives	0.000412116	0.524418
	Mali	0.003502988	0.527921
	Malta	0.001854523	0.529775
	Mauritania	0.002266639	0.532042
	Mauritius	0.000412116	0.532454
	Mayotte	0.000206058	0.53266
	Mexico	0.016072532	0.548733
	Mongolia	0.001236349	0.549969
	Morocco	0.011745312	0.561714
	Mozambique	0.004533278	0.566248
	Myanmar	0.004945395	0.571193
	Namibia	0.000412116	0.571605
	Nepal	0.011127138	0.582732
	Netherlands	0.002678755	0.585411
	Netherlands Antilles	0.000206058	0.585617
	New Zealand	0.001030291	0.586647
	Nicaragua	0.000618174	0.587266
	Niger	0.001854523	0.58912
	Nigeria	0.051102411	0.640223
	Norway	0.002472697	0.642695
	Oman	0.000618174	0.643313
	Pakistan	0.027405728	0.670719
	Panama	0.001648465	0.672368
	Papua New Guinea	0.001442407	0.67381
	Paraguay	0.000412116	0.674222

	Peru	0.024108799	0.698331
	Philippines	0.01957552	0.717906
	Poland	0.002266639	0.720173
	Portugal	0.002884814	0.723058
	Puerto Rico	0.001442407	0.7245
	Qatar	0.000206058	0.724706
	Reunion	0.000412116	0.725118
	Romania	0.003090872	0.728209
	Russia	0.018133114	0.746342
	Rwanda	0.001854523	0.748197
	Sao Tome et Principe	0.000412116	0.748609
	Saudi Arabia	0.003709046	0.752318
	Senegal	0.003709046	0.756027
	Serbia Montenegro	0.001442407	0.75747
	Seychelles	0.000206058	0.757676
	Sierra Leone	0.003090872	0.760767
	Singapore	0.000206058	0.760973
	Slovakia	0.000412116	0.761385
	Slovenia	0.000206058	0.761591
	Solomon Is	0.000206058	0.761797
	Somalia	0.003090872	0.764888
	South Africa	0.025963322	0.790851
	Soviet Union	0.007830208	0.798681
	Spain	0.009066557	0.807748
	Sri Lanka	0.003915104	0.811663
	Sudan	0.012363487	0.824026
	Suriname	0.000618174	0.824645
	Swaziland	0.000412116	0.825057
	Sweden	0.001030291	0.826087

	Switzerland	0.001648465	0.827735
	Syrian Arab Rep	0.004121162	0.831857
	Taiwan (China)	0.004945395	0.836802
	Tajikistan	0.000824232	0.837626
	Tanzania Uni Rep	0.012363487	0.84999
	Thailand	0.009890789	0.85988
	Togo	0.001236349	0.861117
	Tonga	0.000206058	0.861323
	Tunisia	0.00329693	0.86462
	Turkey	0.018339172	0.882959
	Turkmenistan	0.000206058	0.883165
	Turks and Caicos Is	0.000412116	0.883577
	Uganda	0.009272615	0.89285
	Ukraine	0.003090872	0.895941
	United Arab Emirates	0.000824232	0.896765
	United Kingdom	0.014011951	0.910777
	United States	0.035648053	0.946425
	Uruguay	0.001030291	0.947455
	Uzbekistan	0.000412116	0.947867
	Venezuela	0.006387801	0.954255
	Viet Nam	0.008654441	0.96291
	Yemen	0.005151453	0.968061
	Yugoslavia	0.001648465	0.969709
	Zaire/Congo Dem Rep	0.020193695	0.989903
	Zambia	0.003915104	0.993818
	Zimbabwe	0.006181743	1
Transport Accident Total		1	
Volcano	Argentina	0.013333333	0.013333
	Cameroon	0.013333333	0.026667

	Cape Verde Is	0.004444444	0.031111
	Chile	0.031111111	0.062222
	Colombia	0.048888889	0.111111
	Comoros	0.026666667	0.137778
	Costa Rica	0.026666667	0.164444
	Ecuador	0.048888889	0.213333
	El Salvador	0.004444444	0.217778
	Ethiopia	0.013333333	0.231111
	Greece	0.004444444	0.235556
	Guadeloupe	0.004444444	0.24
	Guatemala	0.053333333	0.293333
	Iceland	0.022222222	0.315556
	Indonesia	0.231111111	0.546667
	Italy	0.022222222	0.568889
	Japan	0.066666667	0.635556
	Martinique	0.004444444	0.64
	Mexico	0.044444444	0.684444
	Montserrat	0.017777778	0.702222
	New Zealand	0.008888889	0.711111
	Nicaragua	0.022222222	0.733333
	Papua New Guinea	0.062222222	0.795556
	Peru	0.008888889	0.804444
	Philippines	0.111111111	0.915556
	Reunion	0.004444444	0.92
	Solomon Is	0.004444444	0.924444
	Soviet Union	0.004444444	0.928889
	St Vincent and The Grenadines	0.013333333	0.942222
	Tonga	0.004444444	0.946667

	Trinidad and Tobago	0.004444444	0.951111
	United States	0.008888889	0.96
	Vanuatu	0.022222222	0.982222
	Yemen	0.004444444	0.986667
	Zaire/Congo Dem Rep	0.013333333	1
Volcano Total		1	
Wildfire	Afghanistan	0.002754821	0.002755
	Albania	0.002754821	0.00551
	Algeria	0.005509642	0.011019
	Argentina	0.013774105	0.024793
	Australia	0.082644628	0.107438
	Benin	0.005509642	0.112948
	Bhutan	0.002754821	0.115702
	Bolivia	0.011019284	0.126722
	Bosnia-Hercegovenia	0.002754821	0.129477
	Brazil	0.008264463	0.137741
	Brunei Darussalam	0.002754821	0.140496
	Bulgaria	0.011019284	0.151515
	Canada	0.055096419	0.206612
	Canary Is	0.002754821	0.209366
	Central African Rep	0.005509642	0.214876
	Chile	0.022038567	0.236915
	China P Rep	0.016528926	0.253444
	Colombia	0.008264463	0.261708
	Costa Rica	0.005509642	0.267218
	Croatia	0.013774105	0.280992
	Cuba	0.005509642	0.286501
	Cyprus	0.002754821	0.289256
	Dominican Rep	0.008264463	0.297521

	Ecuador	0.005509642	0.30303
	Ethiopia	0.002754821	0.305785
	France	0.033057851	0.338843
	Gambia The	0.002754821	0.341598
	Germany Fed Rep	0.002754821	0.344353
	Ghana	0.002754821	0.347107
	Greece	0.035812672	0.38292
	Guatemala	0.005509642	0.38843
	Guinea	0.002754821	0.391185
	Guinea Bissau	0.002754821	0.393939
	Honduras	0.002754821	0.396694
	Hong Kong (China)	0.08815427	0.484848
	India	0.005509642	0.490358
	Indonesia	0.024793388	0.515152
	Iran Islam Rep	0.002754821	0.517906
	Israel	0.008264463	0.526171
	Italy	0.019283747	0.545455
	Japan	0.002754821	0.548209
	Kazakhstan	0.002754821	0.550964
	Korea Rep	0.008264463	0.559229
	Lebanon	0.002754821	0.561983
	Macedonia FRY	0.005509642	0.567493
	Malaysia	0.011019284	0.578512
	Mexico	0.008264463	0.586777
	Mongolia	0.008264463	0.595041
	Mozambique	0.002754821	0.597796
	Myanmar	0.005509642	0.603306
	Nepal	0.005509642	0.608815
	New Zealand	0.002754821	0.61157

	Nicaragua	0.008264463	0.619835
	Panama	0.002754821	0.62259
	Papua New Guinea	0.002754821	0.625344
	Paraguay	0.002754821	0.628099
	Peru	0.002754821	0.630854
	Philippines	0.002754821	0.633609
	Poland	0.005509642	0.639118
	Portugal	0.022038567	0.661157
	Russia	0.05785124	0.719008
	Samoa	0.002754821	0.721763
	Serbia Montenegro	0.002754821	0.724518
	Slovakia	0.002754821	0.727273
	South Africa	0.024793388	0.752066
	Soviet Union	0.002754821	0.754821
	Spain	0.035812672	0.790634
	Sudan	0.002754821	0.793388
	Swaziland	0.002754821	0.796143
	Tanzania Uni Rep	0.002754821	0.798898
	Thailand	0.002754821	0.801653
	Turkey	0.013774105	0.815427
	United States	0.170798898	0.986226
	Viet Nam	0.002754821	0.988981
	Yugoslavia	0.005509642	0.99449
	Zaire/Congo Dem Rep	0.005509642	1
Wildfire Total		1	

APPENDIX C

Demand

Country	Type of disaster	Number of victims (Demand)
Afghanistan	Drought	1311600
	Earthquake (seismic activity)	29802
	Epidemic	16954
	Extreme temperature	92721
	Flood	23837
	Industrial Accident	130
	Insect infestation	0
	Mass movement dry	0
	Mass movement wet	50289
	Miscellaneous accident	165
	Storm	11331
	Transport Accident	31
	Wildfire	0
Albania	Drought	3200000
	Earthquake (seismic activity)	1405
	Epidemic	146
	Extreme temperature	3618
	Flood	15220
	Industrial Accident	0
	Mass movement wet	26
	Miscellaneous accident	10300
	Storm	262500
	Transport Accident	19
	Wildfire	75

Algeria	Drought	0
	Earthquake (seismic activity)	80424
	Epidemic	284
	Extreme temperature	0
	Flood	22026
	Industrial Accident	74
	Insect infestation	0
	Mass movement wet	696
	Miscellaneous accident	168
	Storm	3374
	Transport Accident	37
	Wildfire	0
American Samoa	Earthquake (seismic activity)	2500
	Flood	3
	Storm	23060
Angola	Drought	522000
	Epidemic	8180
	Flood	47865
	Industrial Accident	100
	Mass movement wet	0
	Miscellaneous accident	52
	Transport Accident	27
Anguilla	Drought	0
	Epidemic	0
	Flood	0
	Storm	700
	Transport Accident	0
Antigua and Barbuda	Drought	75000
	Storm	7216

Argentina	Drought	0
	Earthquake (seismic activity)	49213
	Epidemic	8625
	Extreme temperature	7125
	Flood	343556
	Industrial Accident	139
	Mass movement wet	16007
	Miscellaneous accident	227
	Storm	8644
	Transport Accident	81
	Volcano	63200
	Wildfire	152752
Armenia	Complex Disasters	3500000
	Drought	297000
	Earthquake (seismic activity)	15000
	Flood	3572
	Industrial Accident	0
	Miscellaneous accident	381
	Transport Accident	48
Australia	Drought	3540000
	Earthquake (seismic activity)	3810
	Epidemic	6
	Extreme temperature	920557
	Flood	8079
	Industrial Accident	2000
	Insect infestation	0
	Mass movement wet	101
	Miscellaneous accident	47
	Storm	89671

	Transport Accident	55
	Wildfire	4638
Austria	Earthquake (seismic activity)	0
	Extreme temperature	0
	Flood	20472
	Industrial Accident	0
	Mass movement wet	5190
	Miscellaneous accident	5
	Storm	300
	Transport Accident	45
Azerbaijan	Drought	0
	Earthquake (seismic activity)	237491
	Flood	262900
	Industrial Accident	0
	Mass movement wet	0
	Transport Accident	60
Azores	Earthquake (seismic activity)	8000
	Mass movement wet	55
	Storm	60
	Transport Accident	0
Bahamas	Flood	0
	Storm	3711
	Transport Accident	289
Bahrain	Epidemic	0
	Industrial Accident	0
	Transport Accident	60
Bangladesh	Complex Disasters	128400
	Drought	8334000
	Earthquake (seismic activity)	3188

	Epidemic	138292
	Extreme temperature	37689
	Flood	4336559
	Industrial Accident	136
	Mass movement wet	27640
	Miscellaneous accident	3937
	Storm	670558
	Transport Accident	101
Barbados	Drought	0
	Earthquake (seismic activity)	1
	Flood	155
	Miscellaneous accident	0
	Storm	2123
Belarus	Epidemic	444
	Extreme temperature	1820
	Flood	21000
	Miscellaneous accident	55
	Storm	21390
	Transport Accident	0
Belgium	Drought	0
	Earthquake (seismic activity)	1030
	Epidemic	104
	Extreme temperature	0
	Flood	1011
	Industrial Accident	116
	Miscellaneous accident	74
	Storm	376
	Transport Accident	80
Belize	Extreme temperature	0

	Flood	19200
	Miscellaneous accident	273
	Storm	35510
	Transport Accident	0
Benin	Drought	1107500
	Epidemic	1057
	Flood	206587
	Industrial Accident	20
	Miscellaneous accident	1028
	Storm	800
	Transport Accident	34
	Wildfire	7200
Bermuda	Storm	40
	Transport Accident	0
Bhutan	Earthquake (seismic activity)	10014
	Epidemic	371
	Flood	800
	Storm	65000
	Wildfire	0
Bolivia	Drought	447651
	Earthquake (seismic activity)	18050
	Epidemic	4289
	Extreme temperature	12641
	Flood	85520
	Industrial Accident	0
	Mass movement wet	34125
	Storm	9370
	Transport Accident	24
	Wildfire	3200

Bosnia-Hercegovenia	Drought	62575
	Epidemic	400
	Extreme temperature	10000
	Flood	41093
	Mass movement wet	403
	Storm	1090
	Transport Accident	11
	Wildfire	0
Botswana	Drought	268980
	Epidemic	12299
	Flood	23843
	Insect infestation	0
	Storm	400
Brazil	Drought	5976500
	Earthquake (seismic activity)	11643
	Epidemic	132158
	Extreme temperature	600
	Flood	203055
	Industrial Accident	91772
	Insect infestation	2000
	Mass movement wet	302677
	Miscellaneous accident	374
	Storm	15221
	Transport Accident	34
	Wildfire	12000
Brunei Darussalam	Wildfire	0
Bulgaria	Drought	0
	Earthquake (seismic activity)	1251
	Extreme temperature	131

	Flood	1937
	Industrial Accident	200
	Mass movement wet	0
	Storm	2925
	Transport Accident	46
	Wildfire	88
Burkina Faso	Drought	1051661
	Epidemic	9015
	Flood	36857
	Industrial Accident	15
	Insect infestation	0
	Miscellaneous accident	200
	Transport Accident	26
Burundi	Complex Disasters	2000000
	Drought	765625
	Earthquake (seismic activity)	120
	Epidemic	98433
	Flood	4078
	Industrial Accident	39
	Storm	8228
	Transport Accident	19
Cambodia	Complex Disasters	900000
	Drought	1637500
	Epidemic	52242
	Flood	931136
	Miscellaneous accident	10184
	Storm	178091
	Transport Accident	13
Cameroon	Drought	293450

	Epidemic	2183
	Flood	5324
	Insect infestation	0
	Mass movement wet	100
	Miscellaneous accident	1755
	Transport Accident	39
	Volcano	6724
Canada	Drought	27500
	Earthquake (seismic activity)	0
	Epidemic	334820
	Extreme temperature	200
	Flood	7478
	Industrial Accident	24757
	Mass movement dry	599
	Miscellaneous accident	1264
	Storm	1039
	Transport Accident	860
	Wildfire	4840
Canary Is	Extreme temperature	113
	Flood	365
	Storm	0
	Transport Accident	167
	Wildfire	405
Cape Verde Is	Drought	20000
	Epidemic	16246
	Flood	0
	Insect infestation	0
	Storm	3861
	Transport Accident	1

	Volcano	6306
Cayman Islands	Storm	300
Central African Rep	Drought	0
	Epidemic	647
	Flood	10743
	Storm	3931
	Transport Accident	18
	Wildfire	418
Chad	Drought	951200
	Epidemic	3986
	Flood	58851
	Insect infestation	0
	Storm	482
	Transport Accident	22
Chile	Drought	120000
	Earthquake (seismic activity)	414419
	Epidemic	40
	Extreme temperature	17220
	Flood	62560
	Industrial Accident	252
	Mass movement wet	41421
	Miscellaneous accident	91
	Storm	45776
	Transport Accident	103
	Volcano	13175
	Wildfire	613
China P Rep	Drought	19410960
	Earthquake (seismic activity)	622123
	Epidemic	1404

	Extreme temperature	10146169
	Flood	11860535
	Industrial Accident	1254
	Insect infestation	0
	Mass movement dry	1368
	Mass movement wet	80062
	Miscellaneous accident	460
	Storm	2755059
	Transport Accident	52
	Wildfire	18872
Colombia	Drought	100000
	Earthquake (seismic activity)	74161
	Epidemic	8569
	Flood	278398
	Industrial Accident	108
	Insect infestation	0
	Mass movement dry	2411
	Mass movement wet	1659
	Miscellaneous accident	4683
	Storm	23400
	Transport Accident	22
	Volcano	6329
	Wildfire	200
Comoros	Complex Disasters	0
	Drought	0
	Epidemic	1260
	Flood	2500
	Storm	28838
	Transport Accident	32

	Volcano	77300
Congo	Drought	0
	Earthquake (seismic activity)	1505
	Epidemic	1201
	Flood	23357
	Mass movement wet	668
	Miscellaneous accident	0
	Transport Accident	144
Cook Is	Epidemic	857
	Miscellaneous accident	0
	Storm	1291
Costa Rica	Drought	0
	Earthquake (seismic activity)	14885
	Epidemic	4786
	Flood	23982
	Industrial Accident	0
	Mass movement wet	200
	Miscellaneous accident	0
	Storm	132048
	Transport Accident	0
	Volcano	22830
	Wildfire	1200
Cote d'Ivoire	Drought	0
	Epidemic	702
	Flood	3969
	Industrial Accident	95000
	Mass movement wet	10006
	Miscellaneous accident	117
	Transport Accident	30

Croatia	Drought	0
	Earthquake (seismic activity)	2000
	Extreme temperature	200
	Flood	632
	Storm	0
	Transport Accident	28
	Wildfire	26
Cuba	Drought	820000
	Earthquake (seismic activity)	2939
	Epidemic	25091
	Flood	50887
	Industrial Accident	1374
	Miscellaneous accident	73
	Storm	467120
	Transport Accident	73
	Wildfire	0
Cyprus	Drought	0
	Earthquake (seismic activity)	983
	Epidemic	280
	Extreme temperature	250
	Miscellaneous accident	377
	Storm	1047
	Transport Accident	8
	Wildfire	0
Czech Rep	Extreme temperature	0
	Flood	40292
	Storm	8
	Transport Accident	46
Czechoslovakia	Extreme temperature	0

	Flood	0
	Industrial Accident	20
	Mass movement wet	0
	Miscellaneous accident	75
	Storm	600
	Transport Accident	106
Denmark	Drought	0
	Industrial Accident	2072
	Miscellaneous accident	100
	Storm	0
	Transport Accident	0
Djibouti	Drought	132001
	Epidemic	809
	Flood	98471
	Industrial Accident	350
	Storm	775
	Transport Accident	54
Dominica	Earthquake (seismic activity)	100
	Storm	12059
	Transport Accident	0
Dominican Rep	Drought	240000
	Earthquake (seismic activity)	2015
	Epidemic	5516
	Flood	84639
	Miscellaneous accident	18
	Storm	141278
	Transport Accident	51
	Wildfire	0
Ecuador	Drought	247167

	Earthquake (seismic activity)	36209
	Epidemic	16369
	Flood	75550
	Industrial Accident	399
	Mass movement dry	0
	Mass movement wet	11658
	Miscellaneous accident	1056
	Transport Accident	58
	Volcano	61043
	Wildfire	800
Egypt	Earthquake (seismic activity)	23249
	Epidemic	72
	Extreme temperature	105
	Flood	29312
	Industrial Accident	521
	Mass movement dry	499
	Miscellaneous accident	346
	Storm	3031
	Transport Accident	30
El Salvador	Drought	400000
	Earthquake (seismic activity)	364284
	Epidemic	8241
	Extreme temperature	0
	Flood	35779
	Industrial Accident	500
	Mass movement wet	0
	Miscellaneous accident	247523
	Storm	26820
	Transport Accident	31

	Volcano	2000
Equatorial Guinea	Epidemic	946
	Miscellaneous accident	510
	Transport Accident	0
Eritrea	Drought	1866667
	Flood	7013
	Insect infestation	0
	Storm	15675
	Transport Accident	27
Estonia	Extreme temperature	0
	Miscellaneous accident	30
	Storm	100
	Transport Accident	140
Ethiopia	Drought	5072452
	Earthquake (seismic activity)	585
	Epidemic	9608
	Flood	51956
	Industrial Accident	200
	Insect infestation	0
	Mass movement dry	0
	Mass movement wet	97
	Miscellaneous accident	7606
	Transport Accident	61
	Volcano	5500
	Wildfire	5
Fiji	Drought	147228
	Earthquake (seismic activity)	0
	Flood	40880
	Storm	30621

	Transport Accident	0
Finland	Flood	400
	Miscellaneous accident	70
	Storm	0
	Transport Accident	31
France	Drought	0
	Earthquake (seismic activity)	2
	Epidemic	6
	Extreme temperature	5100
	Flood	3073
	Industrial Accident	2643
	Mass movement dry	26
	Mass movement wet	95
	Miscellaneous accident	636
	Storm	223038
	Transport Accident	52
	Wildfire	1070
French Guiana	Flood	70000
French Polynesia	Mass movement wet	256
	Storm	4231
	Transport Accident	0
Gabon	Epidemic	2673
	Flood	10000
	Storm	1283
	Transport Accident	11
Gambia The	Drought	276667
	Epidemic	455
	Flood	11271
	Insect infestation	0

	Miscellaneous accident	43000
	Storm	4202
	Transport Accident	11
	Wildfire	5000
Georgia	Drought	696000
	Earthquake (seismic activity)	7553
	Flood	820
	Miscellaneous accident	45
	Storm	900
	Transport Accident	23
Germany	Earthquake (seismic activity)	838
	Epidemic	305
	Extreme temperature	165
	Flood	89460
	Industrial Accident	399
	Mass movement wet	0
	Miscellaneous accident	148
	Storm	3808
	Transport Accident	40
Germany Dem Rep	Industrial Accident	10000
	Storm	0
	Transport Accident	40
Germany Fed Rep	Earthquake (seismic activity)	235
	Extreme temperature	0
	Flood	1756
	Industrial Accident	691
	Miscellaneous accident	46
	Storm	250
	Transport Accident	99

	Wildfire	0
Ghana	Drought	6256000
	Earthquake (seismic activity)	0
	Epidemic	1891
	Flood	241249
	Industrial Accident	0
	Miscellaneous accident	86
	Transport Accident	38
	Wildfire	1500
Greece	Drought	0
	Earthquake (seismic activity)	35570
	Extreme temperature	176
	Flood	1131
	Industrial Accident	170
	Miscellaneous accident	54
	Storm	306
	Transport Accident	11
	Volcano	0
	Wildfire	1132
Grenada	Drought	0
	Flood	0
	Miscellaneous accident	0
	Storm	15715
Guadeloupe	Earthquake (seismic activity)	153
	Epidemic	33000
	Flood	0
	Storm	8021
	Transport Accident	0
	Volcano	75003

Guam	Earthquake (seismic activity)	71
	Storm	4651
	Transport Accident	0
Guatemala	Drought	895532
	Earthquake (seismic activity)	502931
	Epidemic	6719
	Extreme temperature	2247
	Flood	49881
	Industrial Accident	0
	Mass movement dry	3028
	Mass movement wet	8990
	Miscellaneous accident	509
	Storm	125401
	Transport Accident	26
	Volcano	2310
	Wildfire	0
Guinea	Drought	0
	Earthquake (seismic activity)	21436
	Epidemic	2539
	Flood	36532
	Industrial Accident	0
	Miscellaneous accident	0
	Storm	0
	Transport Accident	15
	Wildfire	777
Guinea Bissau	Drought	66000
	Epidemic	13173
	Flood	19514
	Industrial Accident	0

	Insect infestation	0
	Miscellaneous accident	1675
	Storm	2713
	Transport Accident	5
	Wildfire	1500
Guyana	Drought	607200
	Flood	93755
	Industrial Accident	200
	Mass movement wet	0
	Miscellaneous accident	83494
Haiti	Drought	384203
	Earthquake (seismic activity)	3700000
	Epidemic	172307
	Flood	16614
	Industrial Accident	154
	Mass movement wet	1060
	Miscellaneous accident	43668
	Storm	166936
	Transport Accident	26
Honduras	Drought	122946
	Earthquake (seismic activity)	17506
	Epidemic	8846
	Flood	48763
	Industrial Accident	123
	Mass movement dry	0
	Mass movement wet	0
	Miscellaneous accident	90
	Storm	229377
	Transport Accident	39

	Wildfire	0
Hong Kong (China)	Drought	0
	Epidemic	1456
	Extreme temperature	7
	Flood	2617
	Industrial Accident	0
	Mass movement wet	857
	Miscellaneous accident	2818
	Storm	1400
	Transport Accident	66
	Wildfire	4502
Hungary	Drought	0
	Extreme temperature	500
	Flood	20169
	Industrial Accident	7270
	Storm	300
	Transport Accident	24
Iceland	Earthquake (seismic activity)	68
	Flood	280
	Mass movement wet	42
	Volcano	5200
India	Complex Disasters	710000
	Drought	106184100
	Earthquake (seismic activity)	1583050
	Epidemic	10280
	Extreme temperature	83
	Flood	4743750
	Industrial Accident	10908
	Insect infestation	0

	Mass movement dry	0
	Mass movement wet	239945
	Miscellaneous accident	3115
	Storm	964377
	Transport Accident	47
	Wildfire	0
Indonesia	Drought	686317
	Earthquake (seismic activity)	94265
	Epidemic	28710
	Flood	66627
	Industrial Accident	2539
	Mass movement dry	701
	Mass movement wet	14035
	Miscellaneous accident	4340
	Storm	2814
	Transport Accident	59
	Volcano	28001
	Wildfire	505746
Iran Islam Rep	Drought	18812500
	Earthquake (seismic activity)	29949
	Epidemic	2500
	Extreme temperature	0
	Flood	83012
	Industrial Accident	71
	Mass movement wet	48
	Miscellaneous accident	121
	Storm	29966
	Transport Accident	33
	Wildfire	0

Iraq	Drought	500000
	Earthquake (seismic activity)	500
	Epidemic	1456
	Flood	60439
	Industrial Accident	3083
	Miscellaneous accident	263
	Transport Accident	19
Ireland	Epidemic	688
	Flood	1467
	Industrial Accident	700
	Miscellaneous accident	129
	Storm	200
	Transport Accident	0
Israel	Drought	0
	Epidemic	139
	Extreme temperature	0
	Flood	1000
	Industrial Accident	300
	Mass movement wet	13
	Miscellaneous accident	135
	Storm	410
	Transport Accident	103
	Wildfire	10131
Italy	Drought	0
	Earthquake (seismic activity)	39582
	Epidemic	5001
	Extreme temperature	0
	Flood	119388
	Industrial Accident	40481

	Mass movement wet	2450
	Miscellaneous accident	46
	Storm	1054
	Transport Accident	85
	Volcano	7008
	Wildfire	160
Jamaica	Drought	100000
	Earthquake (seismic activity)	90000
	Epidemic	290
	Flood	100412
	Industrial Accident	62
	Mass movement dry	0
	Mass movement wet	0
	Miscellaneous accident	0
	Storm	71782
	Transport Accident	0
Japan	Drought	0
	Earthquake (seismic activity)	35603
	Epidemic	666845
	Extreme temperature	10075
	Flood	300979
	Industrial Accident	31585
	Mass movement wet	3672
	Miscellaneous accident	841
	Storm	92941
	Transport Accident	159
	Volcano	11109
	Wildfire	222
Jordan	Drought	165000

	Earthquake (seismic activity)	0
	Epidemic	715
	Extreme temperature	12
	Flood	6080
	Industrial Accident	7
	Insect infestation	0
	Miscellaneous accident	250
	Storm	113
	Transport Accident	34
Kazakhstan	Earthquake (seismic activity)	36626
	Epidemic	291
	Extreme temperature	300006
	Flood	14921
	Industrial Accident	55
	Mass movement wet	0
	Miscellaneous accident	53
	Storm	0
	Transport Accident	3
	Wildfire	8000
Kenya	Drought	3620833
	Earthquake (seismic activity)	0
	Epidemic	245786
	Flood	67767
	Industrial Accident	203
	Mass movement wet	13
	Miscellaneous accident	4573
	Storm	0
	Transport Accident	31
Kiribati	Drought	84000

	Epidemic	352
	Flood	85
	Storm	700
Korea Dem P Rep	Complex Disasters	8000000
	Earthquake (seismic activity)	0
	Epidemic	1600
	Flood	570131
	Industrial Accident	0
	Miscellaneous accident	61
	Storm	114205
	Transport Accident	14171
Korea Rep	Drought	2800000
	Epidemic	10356
	Extreme temperature	0
	Flood	108732
	Industrial Accident	3790
	Mass movement wet	2563
	Miscellaneous accident	367
	Storm	20039
	Transport Accident	42
	Wildfire	1717
Kuwait	Epidemic	1
	Flood	200
	Miscellaneous accident	76
Kyrgyzstan	Drought	2000000
	Earthquake (seismic activity)	25714
	Epidemic	312
	Extreme temperature	0
	Flood	3541

	Industrial Accident	600
	Mass movement wet	11360
	Miscellaneous accident	600
	Storm	9075
	Transport Accident	14
Lao P Dem Rep	Drought	1416667
	Epidemic	4982
	Flood	230314
	Miscellaneous accident	0
	Storm	287240
	Transport Accident	5
Latvia	Epidemic	102
	Extreme temperature	0
	Storm	0
Lebanon	Earthquake (seismic activity)	200
	Flood	9250
	Industrial Accident	0
	Mass movement dry	0
	Miscellaneous accident	27
	Storm	52288
	Transport Accident	22
	Wildfire	15
Lesotho	Drought	420750
	Epidemic	1399
	Flood	61667
	Storm	1350
	Transport Accident	60
Liberia	Drought	0
	Epidemic	2959

	Extreme temperature	1000000
	Flood	7682
	Insect infestation	500000
	Mass movement dry	200
	Miscellaneous accident	950
	Storm	2750
	Transport Accident	16
Libyan Arab Jamah	Earthquake (seismic activity)	0
	Flood	0
	Industrial Accident	0
	Insect infestation	0
	Miscellaneous accident	50
	Transport Accident	32
Lithuania	Drought	0
	Extreme temperature	0
	Flood	0
	Miscellaneous accident	0
	Storm	780000
	Transport Accident	0
Luxembourg	Extreme temperature	0
	Flood	0
	Storm	0
	Transport Accident	0
Macau	Epidemic	1
	Miscellaneous accident	1418
	Storm	997
	Transport Accident	133
Macedonia FRY	Drought	10000
	Epidemic	200

	Extreme temperature	202
	Flood	15914
	Storm	3
	Transport Accident	15
	Wildfire	1000000
Madagascar	Drought	585882
	Epidemic	8285
	Flood	27368
	Insect infestation	0
	Miscellaneous accident	253
	Storm	223764
	Transport Accident	15
Malawi	Drought	3279784
	Earthquake (seismic activity)	23612
	Epidemic	5728
	Flood	67537
	Miscellaneous accident	0
	Storm	8
	Transport Accident	48
Malaysia	Drought	5000
	Earthquake (seismic activity)	5063
	Epidemic	2913
	Flood	34779
	Industrial Accident	1631
	Mass movement dry	0
	Mass movement wet	97
	Miscellaneous accident	2325
	Storm	8278
	Transport Accident	12

	Wildfire	3000
Maldives	Earthquake (seismic activity)	27214
	Epidemic	6274
	Flood	975
	Storm	23849
	Transport Accident	100
Mali	Drought	1066167
	Epidemic	1658
	Flood	12852
	Insect infestation	0
	Miscellaneous accident	1720
	Transport Accident	27
Malta	Transport Accident	6
Marshall Is	Epidemic	218
	Flood	600
	Storm	6000
Martinique	Earthquake (seismic activity)	100
	Epidemic	29200
	Storm	4446
	Volcano	0
Mauritania	Drought	739891
	Epidemic	739
	Flood	11786
	Insect infestation	0
	Storm	239
	Transport Accident	14
Mauritius	Drought	0
	Epidemic	1331
	Storm	85772

	Transport Accident	0
Mayotte	Transport Accident	12
Mexico	Drought	1282500
	Earthquake (seismic activity)	107582
	Epidemic	17737
	Extreme temperature	68000
	Flood	109717
	Industrial Accident	5309
	Mass movement wet	160
	Miscellaneous accident	57
	Storm	131755
	Transport Accident	86
	Volcano	20239
	Wildfire	0
Micronesia Fed States	Drought	28800
	Epidemic	3431
	Flood	0
	Storm	1767
Moldova Rep	Drought	210394
	Epidemic	1647
	Extreme temperature	0
	Flood	7422
	Storm	1312790
Mongolia	Drought	450000
	Earthquake (seismic activity)	0
	Epidemic	1089
	Extreme temperature	769113
	Flood	72663
	Industrial Accident	0

	Storm	402200
	Transport Accident	8
	Wildfire	5061
Montenegro	Flood	1972
Montserrat	Storm	12040
	Volcano	3300
Morocco	Drought	206000
	Earthquake (seismic activity)	19233
	Epidemic	2942
	Extreme temperature	0
	Flood	30403
	Industrial Accident	1006
	Insect infestation	0
	Mass movement dry	0
	Mass movement wet	12216
	Miscellaneous accident	960
	Storm	0
	Transport Accident	27
Mozambique	Drought	1614318
	Earthquake (seismic activity)	1476
	Epidemic	15273
	Flood	347734
	Industrial Accident	200
	Insect infestation	0
	Mass movement wet	2500
	Miscellaneous accident	450
	Storm	255669
	Transport Accident	4610
	Wildfire	3023

Myanmar	Earthquake (seismic activity)	12379
	Epidemic	800
	Flood	153945
	Industrial Accident	91
	Mass movement wet	48789
	Miscellaneous accident	11049
	Storm	281132
	Transport Accident	34
	Wildfire	39294
Namibia	Drought	195800
	Epidemic	2531
	Flood	98573
	Transport Accident	9
Nepal	Drought	1225750
	Earthquake (seismic activity)	145990
	Epidemic	10925
	Extreme temperature	8403
	Flood	137744
	Mass movement dry	0
	Mass movement wet	73770
	Miscellaneous accident	94
	Storm	92
	Transport Accident	28
	Wildfire	27000
Netherlands	Earthquake (seismic activity)	20
	Epidemic	200
	Extreme temperature	0
	Flood	105000
	Industrial Accident	0

	Miscellaneous accident	1065
	Storm	83367
	Transport Accident	34
Netherlands Antilles	Storm	40000
	Transport Accident	4
New Caledonia	Epidemic	437
	Storm	1550
New Zealand	Drought	0
	Earthquake (seismic activity)	103364
	Epidemic	1
	Extreme temperature	0
	Flood	887
	Industrial Accident	4715
	Mass movement wet	600
	Miscellaneous accident	1200
	Storm	708
	Transport Accident	20
	Volcano	70
	Wildfire	130
Nicaragua	Complex Disasters	12500
	Drought	184333
	Earthquake (seismic activity)	147179
	Epidemic	2003
	Flood	36005
	Industrial Accident	13150
	Mass movement wet	5769
	Miscellaneous accident	90
	Storm	100536
	Transport Accident	0

	Volcano	64274
	Wildfire	16000
Niger	Drought	2628340
	Epidemic	7819
	Flood	43872
	Industrial Accident	0
	Insect infestation	0
	Miscellaneous accident	1625
	Storm	1253
	Transport Accident	16
Nigeria	Drought	3000000
	Epidemic	6592
	Extreme temperature	0
	Flood	88851
	Industrial Accident	1450
	Insect infestation	0
	Mass movement wet	900
	Miscellaneous accident	2307
	Storm	506
	Transport Accident	19
Niue	Epidemic	297
	Storm	1626
Northern Mariana Is	Storm	250
Norway	Flood	2033
	Industrial Accident	0
	Mass movement wet	0
	Storm	300
	Transport Accident	21
Oman	Storm	5376

	Transport Accident	11
Pakistan	Drought	2200000
	Earthquake (seismic activity)	312933
	Epidemic	2061
	Extreme temperature	144
	Flood	1346148
	Industrial Accident	1841
	Insect infestation	0
	Mass movement dry	0
	Mass movement wet	3095
	Miscellaneous accident	506
	Storm	200332
	Transport Accident	58
Palau	Miscellaneous accident	12004
Palestine (West Bank)	Epidemic	943
	Flood	500
	Industrial Accident	20
	Miscellaneous accident	765
Panama	Complex Disasters	3000
	Drought	81000
	Earthquake (seismic activity)	5378
	Epidemic	1389
	Flood	6635
	Miscellaneous accident	1234
	Storm	4200
	Transport Accident	14
	Wildfire	1436
Papua New Guinea	Drought	270000
	Earthquake (seismic activity)	5104

	Epidemic	2200
	Flood	32799
	Industrial Accident	60
	Mass movement dry	1000
	Mass movement wet	2300
	Storm	69893
	Transport Accident	4
	Volcano	19369
	Wildfire	8000
Paraguay	Drought	64878
	Epidemic	17275
	Extreme temperature	0
	Flood	66055
	Miscellaneous accident	300
	Storm	12586
	Transport Accident	6
	Wildfire	125000
Peru	Drought	721221
	Earthquake (seismic activity)	215104
	Epidemic	51878
	Extreme temperature	708561
	Flood	87768
	Industrial Accident	1033
	Insect infestation	0
	Mass movement dry	0
	Mass movement wet	49417
	Miscellaneous accident	819
	Storm	333706
	Transport Accident	27

	Volcano	3500
	Wildfire	1000
Philippines	Drought	1092201
	Earthquake (seismic activity)	123517
	Epidemic	10447
	Flood	163307
	Industrial Accident	2662
	Insect infestation	200
	Mass movement dry	0
	Mass movement wet	16712
	Miscellaneous accident	2899
	Storm	452286
	Transport Accident	135
	Volcano	75431
	Wildfire	300
Poland	Earthquake (seismic activity)	1050
	Extreme temperature	0
	Flood	30715
	Industrial Accident	33
	Miscellaneous accident	133
	Storm	681
	Transport Accident	32
	Wildfire	0
Portugal	Drought	0
	Extreme temperature	0
	Flood	4118
	Miscellaneous accident	1263
	Storm	135
	Transport Accident	58

	Wildfire	50062
Puerto Rico	Drought	0
	Earthquake (seismic activity)	0
	Flood	4162
	Industrial Accident	1850
	Mass movement wet	0
	Miscellaneous accident	90
	Storm	23955
	Transport Accident	14
Qatar	Transport Accident	0
Reunion	Epidemic	157000
	Storm	3509
	Transport Accident	0
	Volcano	1000
Romania	Drought	0
	Earthquake (seismic activity)	98213
	Epidemic	1757
	Extreme temperature	453
	Flood	44012
	Industrial Accident	51
	Mass movement wet	330
	Miscellaneous accident	2
	Storm	1057
	Transport Accident	7
Russia	Drought	1000000
	Earthquake (seismic activity)	6019
	Epidemic	15825
	Extreme temperature	63134
	Flood	48336

	Industrial Accident	204
	Insect infestation	0
	Mass movement dry	1750
	Mass movement wet	404
	Miscellaneous accident	96
	Storm	2365
	Transport Accident	18
	Wildfire	18267
Rwanda	Drought	692758
	Earthquake (seismic activity)	1143
	Epidemic	673
	Flood	219016
	Industrial Accident	0
	Mass movement wet	3969
	Transport Accident	42
Samoa	Earthquake (seismic activity)	5585
	Flood	0
	Storm	75801
	Wildfire	1000
Sao Tome et Principe	Drought	93000
	Epidemic	1063
	Transport Accident	17
Saudi Arabia	Epidemic	190
	Flood	3704
	Industrial Accident	10
	Miscellaneous accident	211
	Storm	0
	Transport Accident	42
Senegal	Drought	1399833

	Epidemic	3618
	Flood	61244
	Industrial Accident	365
	Insect infestation	0
	Miscellaneous accident	190
	Storm	48427
	Transport Accident	34
Serbia	Earthquake (seismic activity)	27030
	Extreme temperature	500
	Flood	5120
Serbia Montenegro	Earthquake (seismic activity)	100
	Epidemic	435
	Extreme temperature	70
	Flood	13933
	Industrial Accident	15
	Miscellaneous accident	307
	Storm	0
	Transport Accident	74
	Wildfire	12
Seychelles	Earthquake (seismic activity)	4830
	Epidemic	5461
	Flood	1237
	Storm	6800
	Transport Accident	0
Sierra Leone	Epidemic	1034
	Flood	44241
	Industrial Accident	7
	Mass movement wet	5
	Miscellaneous accident	43

	Storm	5002
	Transport Accident	24
Singapore	Epidemic	746
	Industrial Accident	120
	Miscellaneous accident	1200
	Transport Accident	117
Slovakia	Extreme temperature	89
	Flood	8166
	Industrial Accident	200
	Miscellaneous accident	0
	Storm	10324
	Transport Accident	22
	Wildfire	0
Slovenia	Earthquake (seismic activity)	653
	Extreme temperature	0
	Flood	0
	Industrial Accident	0
	Storm	1050
	Transport Accident	0
Solomon Is	Drought	380
	Earthquake (seismic activity)	1253
	Flood	11509
	Storm	25316
	Transport Accident	24
	Volcano	6000
Somalia	Drought	1272938
	Earthquake (seismic activity)	105083
	Epidemic	5218
	Flood	87007

	Miscellaneous accident	1420
	Storm	0
	Transport Accident	18
South Africa	Drought	3495000
	Earthquake (seismic activity)	241
	Epidemic	18731
	Extreme temperature	0
	Flood	17606
	Industrial Accident	442
	Mass movement wet	0
	Miscellaneous accident	1037
	Storm	35544
	Transport Accident	65
	Wildfire	1476
Soviet Union	Complex Disasters	0
	Drought	5000000
	Earthquake (seismic activity)	144349
	Epidemic	18000000
	Flood	11479
	Industrial Accident	107767
	Mass movement dry	4253
	Mass movement wet	2500
	Miscellaneous accident	13
	Storm	10000
	Transport Accident	98
	Volcano	0
	Wildfire	0
Spain	Drought	6000000
	Earthquake (seismic activity)	5130

	Epidemic	712
	Extreme temperature	70
	Flood	46823
	Industrial Accident	9594
	Mass movement wet	129
	Miscellaneous accident	298
	Storm	15103
	Transport Accident	41
	Wildfire	2674
Sri Lanka	Drought	1251200
	Earthquake (seismic activity)	1019306
	Epidemic	35603
	Flood	243014
	Industrial Accident	0
	Mass movement wet	130
	Miscellaneous accident	24027
	Storm	300434
	Transport Accident	54
St Helena	Storm	300
St Kitts and Nevis	Flood	0
	Storm	3570
St Lucia	Drought	0
	Earthquake (seismic activity)	0
	Flood	2000
	Mass movement wet	175
	Storm	16990
St Vincent and The Grenadines	Flood	407
	Storm	4740
	Volcano	11000

Sudan	Complex Disasters	2600000
	Drought	3930000
	Earthquake (seismic activity)	4008
	Epidemic	6863
	Flood	194580
	Industrial Accident	4150
	Insect infestation	0
	Miscellaneous accident	953
	Storm	30
	Transport Accident	27
	Wildfire	0
Suriname	Flood	12049
	Transport Accident	13
Swaziland	Drought	543333
	Epidemic	1839
	Flood	137250
	Storm	213395
	Transport Accident	59
	Wildfire	1500
Sweden	Epidemic	350
	Extreme temperature	0
	Flood	0
	Industrial Accident	0
	Mass movement wet	50
	Miscellaneous accident	162
	Storm	0
	Transport Accident	61
Switzerland	Epidemic	1
	Extreme temperature	0

	Flood	1867
	Industrial Accident	1735
	Mass movement wet	642
	Miscellaneous accident	9
	Storm	38
	Transport Accident	25
Syrian Arab Rep	Drought	814500
	Epidemic	2083
	Flood	122500
	Industrial Accident	22
	Mass movement wet	23
	Miscellaneous accident	10020
	Storm	176
	Transport Accident	22
Taiwan (China)	Earthquake (seismic activity)	24584
	Epidemic	125155
	Flood	4886
	Industrial Accident	715
	Mass movement wet	134
	Miscellaneous accident	26
	Storm	98757
	Transport Accident	83
Tajikistan	Drought	1900000
	Earthquake (seismic activity)	5429
	Epidemic	4809
	Extreme temperature	2000000
	Flood	34431
	Industrial Accident	1600
	Insect infestation	0

	Mass movement dry	0
	Mass movement wet	13912
	Miscellaneous accident	2
	Storm	1165
	Transport Accident	7
Tanzania Uni Rep	Drought	1273748
	Earthquake (seismic activity)	1798
	Epidemic	3856
	Flood	31327
	Industrial Accident	0
	Insect infestation	0
	Mass movement wet	150
	Miscellaneous accident	3498
	Storm	946
	Transport Accident	50
	Wildfire	0
Thailand	Drought	5996520
	Earthquake (seismic activity)	33512
	Epidemic	6196
	Flood	875600
	Industrial Accident	1670
	Mass movement wet	14370
	Miscellaneous accident	1382
	Storm	184152
	Transport Accident	50
	Wildfire	0
Timor-Leste	Drought	0
	Epidemic	336
	Flood	1126

	Storm	8730
Togo	Complex Disasters	50000
	Drought	275000
	Epidemic	1298
	Flood	59160
	Storm	15
	Transport Accident	98
Tokelau	Storm	619
Tonga	Earthquake (seismic activity)	3006
	Storm	19159
	Transport Accident	54
	Volcano	2500
Trinidad and Tobago	Drought	0
	Earthquake (seismic activity)	17
	Flood	105
	Industrial Accident	0
	Mass movement wet	1200
	Miscellaneous accident	110
	Storm	17187
	Volcano	200
Tunisia	Drought	31400
	Earthquake (seismic activity)	0
	Flood	42713
	Industrial Accident	147
	Insect infestation	0
	Miscellaneous accident	127
	Transport Accident	92
Turkey	Earthquake (seismic activity)	113508
	Epidemic	29265

	Extreme temperature	2817
	Flood	71141
	Industrial Accident	53
	Mass movement dry	1069
	Mass movement wet	2248
	Miscellaneous accident	122
	Storm	3410
	Transport Accident	31
	Wildfire	383
Turkmenistan	Earthquake (seismic activity)	0
	Flood	420
	Miscellaneous accident	0
	Transport Accident	0
Turks and Caicos Is	Storm	618
	Transport Accident	118
Tuvalu	Drought	0
	Miscellaneous accident	0
	Storm	517
Uganda	Drought	552778
	Earthquake (seismic activity)	19170
	Epidemic	4453
	Flood	63900
	Mass movement wet	8081
	Miscellaneous accident	10034
	Storm	2538
	Transport Accident	15
Ukraine	Epidemic	2257
	Extreme temperature	59600
	Flood	239845

	Industrial Accident	53
	Miscellaneous accident	987
	Storm	11332
	Transport Accident	51
United Arab Emirates	Industrial Accident	100
	Miscellaneous accident	15
	Transport Accident	2
United Kingdom	Earthquake (seismic activity)	4501
	Epidemic	49
	Extreme temperature	47
	Flood	20146
	Industrial Accident	2074
	Mass movement wet	0
	Miscellaneous accident	143
	Storm	28920
	Transport Accident	206
United States	Drought	0
	Earthquake (seismic activity)	2999
	Epidemic	81341
	Extreme temperature	31
	Flood	127858
	Industrial Accident	5374
	Mass movement wet	70
	Miscellaneous accident	172
	Storm	78289
	Transport Accident	191
	Volcano	2500
	Wildfire	18818
Uruguay	Drought	0

	Extreme temperature	1200
	Flood	18897
	Miscellaneous accident	8
	Storm	852
	Transport Accident	42
Uzbekistan	Drought	600000
	Earthquake (seismic activity)	25043
	Epidemic	148
	Flood	1500
	Mass movement dry	400
	Mass movement wet	0
	Miscellaneous accident	9173
	Transport Accident	0
Vanuatu	Earthquake (seismic activity)	3776
	Flood	1976
	Mass movement wet	3000
	Storm	24257
	Volcano	4725
Venezuela	Drought	0
	Earthquake (seismic activity)	14818
	Epidemic	10718
	Flood	35578
	Industrial Accident	10381
	Mass movement wet	7173
	Miscellaneous accident	46
	Storm	3815
	Transport Accident	19
Viet Nam	Drought	1527500
	Epidemic	4108

	Flood	478622
	Industrial Accident	582
	Insect infestation	0
	Mass movement wet	7815
	Miscellaneous accident	1418
	Storm	615910
	Transport Accident	16
	Wildfire	0
Virgin Is (UK)	Storm	3
Virgin Is (US)	Storm	10000
Wallis	Earthquake (seismic activity)	20
Wallis and Futuna Is	Storm	4500
Yemen	Earthquake (seismic activity)	40039
	Epidemic	234
	Flood	21883
	Industrial Accident	95
	Mass movement wet	11
	Miscellaneous accident	21
	Storm	0
	Transport Accident	21
	Volcano	15
Yemen Arab Rep	Drought	2020000
	Earthquake (seismic activity)	401500
	Flood	67621
	Insect infestation	0
Yemen P Dem Rep	Drought	0
	Flood	176250
	Miscellaneous accident	500
Yugoslavia	Drought	0

	Earthquake (seismic activity)	64336
	Epidemic	174
	Extreme temperature	0
	Flood	87000
	Industrial Accident	33
	Miscellaneous accident	0
	Transport Accident	53
	Wildfire	0
Zaire/Congo Dem Rep	Drought	400000
	Earthquake (seismic activity)	7089
	Epidemic	12141
	Flood	13509
	Industrial Accident	12
	Mass movement wet	694
	Miscellaneous accident	154
	Storm	20607
	Transport Accident	63
	Volcano	85200
	Wildfire	1448
Zambia	Drought	1391068
	Epidemic	4087
	Flood	322382
	Industrial Accident	650
	Insect infestation	0
	Mass movement wet	150
	Miscellaneous accident	115
	Transport Accident	34
Zimbabwe	Drought	2967000
	Epidemic	29656

	Flood	55303
	Industrial Accident	1
	Miscellaneous accident	150
	Storm	0
	Transport Accident	79

APPENDIX D

Country Name	Country Code	Latitude	Longitude	Region	Continent	Distance between country and Main warehouse(KM)
Afghanistan	1	34.52	69.18	Southern Asia	Asia	8109
Albania	2	41.33	19.82	Southern Europe	Europe	3687
Algeria	3	36.76	3.05	Northern Africa	Africa	2118
American Samoa	4	-14.28	-170.7	Polynesia	Oceania	16376
Andorra	227	42.5	1.52	Middle Africa	Africa	2503
Angola	5	-8.84	13.23	Caribbean	Americas	3800
Anguilla	6	18.22	-63.05	Caribbean	Americas	5239
Antigua and Barbuda	7	17.12	-61.85	South America	Americas	5126
Argentina	8	-34.58	-58.41	Western Asia	Asia	7298
Armenia	9	40.18	44.51	Australia and New Zealand	Oceania	5857
Aruba	228	12.52	-70.03	Western Europe	Europe	5987
Australia	10	-35.28	149.13	Western Asia	Asia	16935
Austria	11	48.21	16.37	Caribbean	Americas	3863
Azerbaijan	12	40.4	49.88	Western Asia	Asia	6373
Bahamas	14	25.08	-77.35	Southern Asia	Asia	6678
Bahrain	15	26.24	50.58	Caribbean	Americas	6155
Bangladesh	16	23.72	90.41	Eastern Europe	Europe	10117
Barbados	17	13.1	-59.62	Western	Europe	4949

				Europe		
Belarus	18	53.9	27.57	Central America	Americas	5070
Belgium	19	50.85	4.35	Western Africa	Africa	3374
Belize	20	17.25	-88.77	Northern America	Americas	7813
Benin	21	6.48	2.62	Southern Asia	Asia	1947
Bermuda	22	32.29	-64.78	South America	Americas	5530
Bhutan	23	27.48	89.6	Southern Europe	Europe	10055
Bolivia	24	-16.5	-68.15	Southern Asia	Asia	6841
Bosnia and Herzegovina	25	43.85	18.38	South America	Americas	3720
Botswana	16	-24.65	25.91	South-Eastern Asia	Asia	5827
Brazil	27	-15.78	-47.93	Eastern Europe	Europe	5209
British Indian Ocean Territory	229	7.24	72.46	Western Africa	Africa	8425
British Virgin Islands	217	18.42	-64.62	Eastern Africa	Africa	5395
Brunei	28	4.88	114.93	South-Eastern Asia	Asia	12663
Bulgaria	29	42.7	23.32	Middle Africa	Africa	4055
Burkina Faso	30	12.37	-1.52	Northern America	Americas	1239
Burundi	31	-3.38	29.36	Western Africa	Africa	4674
Cambodia	32	11.55	104.92	Caribbean	Americas	11600
Cameroon	33	3.87	11.52	Middle Africa	Africa	2787
Canada	34	45.42	-75.69	Middle Africa	Africa	6953
Cape Verde	36	14.92	-23.52	South America	Americas	1403
Cayman Islands	37	19.3	-81.38	Eastern Asia	Asia	7068
Central African	38	4.37	18.58	South America	Americas	3352

Republic						
Chad	39	12.11	15.05	Eastern Africa	Africa	2715
Chile	40	-33.43	-70.57	Polynesia	Oceania	8068
China	41	39.91	116.4	Central America	Americas	12857
Christmas Island	231	-10.42	105.72	Southern Europe	Europe	12051
Cocos Islands	232	13.5	116.02	Caribbean	Americas	12694
Colombia	42	4.6	-74.08	Western Asia	Asia	6537
Comoros	43	-11.7	43.24	Eastern Europe	Europe	6292
Cook Islands	45	-21.21	-159.78	Middle Africa	Africa	15483
Costa Rica	46	9.93	-84.08	Northern Europe	Europe	7414
Croatia	48	45.8	16	Eastern Africa	Africa	3668
Cuba	49	23.13	-82.36	Caribbean	Americas	7169
Cyprus	50	35.17	33.37	Caribbean	Americas	4641
Czech Republic	51	50.09	14.42	South America	Americas	3870
Democratic Republic of the Congo	44	-4.33	15.32	Northern Africa	Africa	3609
Denmark	53	55.68	12.57	Central America	Americas	4205
Djibouti	54	11.6	43.15	Middle Africa	Africa	5462
Dominica	55	15.3	-61.4	Eastern Africa	Africa	5097
Dominican Republic	56	18.47	-69.9	Northern Europe	Europe	5922
East Timor	233	-8.56	125.57	Eastern Africa	Africa	13939
Ecuador	57	-0.22	-78.5	Melanesia	Oceania	7093
Egypt	58	30.05	31.25	Northern Europe	Europe	4300
El Salvador	59	13.71	-89.2	Western Europe	Europe	7879

Equatorial Guinea	60	3.75	8.78	South America	Americas	2581
Eritrea	61	15.33	38.93	Polynesia	Oceania	4993
Estonia	62	59.44	24.75	Middle Africa	Africa	5255
Ethiopia	63	9.03	38.7	Western Africa	Africa	5077
Falkland Islands	234	-51.7	-57.85	Western Asia	Asia	8636
Faroe Islands	235	62.02	-6.77	Western Europe	Europe	4154
Fiji	64	-18.13	178.42	Western Africa	Africa	19307
Finland	65	60.18	24.93	Southern Europe	Europe	5322
France	66	48.85	2.35	Caribbean	Americas	3107
French Guiana	67	4.93	-52.33	Caribbean	Americas	4449
French Polynesia	68	-17.53	-149.57	Micronesia	Oceania	14401
French Southern Territories	236	-37.8	77.51	Central America	Americas	10584
Gabon	69	0.38	9.45	Western Africa	Africa	2860
Gambia	70	13.46	-16.58	Western Africa	Africa	929
Georgia	71	41.73	44.79	South America	Americas	5937
Germany	72	52.52	13.4	Caribbean	Americas	3995
Ghana	75	5.55	-0.22	Central America	Americas	1840
Gibraltar	237	36.13	-5.35	Eastern Asia	Asia	1637
Greece	76	37.98	23.73	Eastern Europe	Europe	3855
Greenland	238	64.17	-51.74	Northern Europe	Europe	5980
Grenada	77	12.05	-61.75	Southern Asia	Asia	5176
Guadeloupe	78	16	-61.72	South-Eastern Asia	Asia	5122
Guam	79	13.47	144.75	Southern Asia	Asia	15563

Guatemala	80	14.62	-90.53	Western Asia	Asia	8004
Guernsey	239	49.46	-2.54	Northern Europe	Europe	2993
Guinea	81	9.51	-13.71	Western Asia	Asia	1155
Guinea-Bissau	82	11.85	-15.58	Southern Europe	Europe	1007
Guyana	83	6.8	-58.17	Western Africa	Africa	4944
Haiti	84	18.54	-72.34	Caribbean	Americas	6166
Honduras	85	14.1	-87.22	Eastern Asia	Asia	7678
Hong Kong	86	22.28	114.15	Western Asia	Asia	12488
Hungary	87	47.5	19.08	Central Asia	Asia	4010
Iceland	88	64.15	-21.95	Eastern Africa	Africa	4491
India	89	28.61	77.23	Micronesia	Oceania	8830
Indonesia	90	-6.17	106.83	Western Asia	Asia	12057
Iran	91	35.67	51.42	Central Asia	Asia	6392
Iraq	92	33.34	44.39	South-Eastern Asia	Asia	5655
Ireland	93	53.33	-6.25	Northern Europe	Europe	3297
Isle of Man	240	54.15	-4.48	Western Asia	Asia	3406
Israel	94	31.77	35.23	Southern Africa	Africa	4727
Italy	95	41.9	12.48	Western Africa	Africa	3145
Ivory Coast	47	6.82	-5.28	Northern Africa	Africa	1487
Jamaica	96	18	-76.79	Northern Europe	Europe	6613
Japan	97	35.67	139.78	Western Europe	Europe	15124
Jersey	241	49.18	-2.1	Eastern Asia	Asia	2979
Jordan	98	31.95	35.93	Souther	Europe	4799

				n Europe		
Kazakhstan	99	51.18	71.43	Eastern Africa	Africa	8763
Kenya	100	-1.28	36.82	Eastern Africa	Africa	5236
Kiribati	101	1.33	172.98	South-Eastern Asia	Asia	18471
Kosovo	242	42.67	21.17	Southern Asia	Asia	3874
Kuwait	104	29.37	47.98	Western Africa	Africa	5934
Kyrgyzstan	105	42.87	74.6	Western Africa	Africa	8816
Laos	106	17.97	102.6	Micronesia	Oceania	11335
Latvia	107	56.95	24.1	Caribbean	Americas	5029
Lebanon	108	33.87	35.51	Western Africa	Africa	4808
Lesotho	109	-29.32	27.48	Eastern Africa	Africa	6291
Liberia	110	6.31	-10.8	Eastern Africa	Africa	1436
Libya	111	32.89	13.18	Central America	Americas	2684
Liechtenstein	243	47.14	9.52	Micronesia	Oceania	3332
Lithuania	112	54.68	25.32	Eastern Europe	Europe	4955
Luxembourg	113	49.61	6.13	Eastern Asia	Asia	3349
Macao	114	22.2	113.55	Southern Europe	Europe	12428
Macedonia	115	42	21.43	Caribbean	Americas	3858
Madagascar	116	-18.92	47.52	Northern Africa	Africa	7042
Malawi	117	-13.98	33.78	Eastern Africa	Africa	5639
Malaysia	118	3.17	101.7	South-Eastern Asia	Asia	11377
Maldives	119	4.18	73.51	Southern Africa	Africa	8582
Mali	120	12.65	-8	Southern Asia	Asia	846
Malta	121	35.9	14.51	Western	Europe	2947

				Europe		
Marshall Islands	122	7.1	171.38	Caribbean	Americas	18260
Martinique	123	14.6	-61.08	Melanesia	Oceania	5073
Mauritania	124	18.12	-16.04	Australia and New Zealand	Oceania	590
Mauritius	125	-20.16	57.5	Central America	Americas	7950
Mayotte	126	-12.78	45.23	Western Africa	Africa	6518
Mexico	127	19.43	-99.14	Western Africa	Africa	8843
Micronesia	128	6.92	158.15	Polynesia	Oceania	16943
Moldova	129	47.01	28.86	Eastern Asia	Asia	4754
Monaco	244	43.73	7.42	Micronesia	Oceania	2934
Mongolia	130	47.92	106.92	Northern Europe	Europe	12075
Montenegro	131	42.44	19.26	Western Asia	Asia	3705
Montserrat	132	16.7	-62.22	Southern Asia	Asia	5166
Morocco	133	34.02	-6.83	Southern Asia	Asia	1391
Mozambique	134	-25.97	32.59	Western Asia	Asia	6364
Myanmar	135	16.81	96.16	Central America	Americas	10695
Namibia	136	-22.57	17.08	Melanesia	Oceania	5140
Nauru	245	-0.54	166.93	South America	Americas	17891
Nepal	137	27.72	85.32	South America	Americas	9630
Netherlands	138	52.37	4.9	South-Eastern Asia	Asia	3534
Netherlands Antilles	139	12.1	-68.92	Eastern Europe	Europe	5883
New Caledonia	140	-22.27	166.45	Southern Europe	Europe	18230
New Zealand	141	-41.28	174.78	Caribbean	Americas	19557
Nicaragua	142	12.15	-86.27	Caribbe	Americas	7603

				an		
Niger	143	13.52	2.12	Eastern Africa	Africa	1469
Nigeria	144	9.08	7.53	Eastern Europe	Europe	2161
Niue	145	-19.02	-169.92	Eastern Europe	Europe	16408
Norfolk Island	246	18	-76.79	Eastern Africa	Africa	6613
North Korea	102	39.02	125.75	Western Africa	Africa	13770
Northern Mariana Islands	146	15.27	145.8	Caribbean	Americas	15661
Norway	147	59.91	10.74	Caribbean	Americas	4473
Oman	148	23.61	58.59	Caribbean	Americas	6937
Pakistan	149	33.61	73.06	Polynesia	Oceania	8477
Palau	150	7.34	134.47	Polynesia	Oceania	14580
Palestinian Territory	151	31.77	35.23	Western Asia	Asia	4727
Panama	152	8.97	-79.53	Western Africa	Africa	6980
Papua New Guinea	153	-9.46	147.19	Southern Europe	Europe	16075
Paraguay	154	-25.27	-57.67	Eastern Africa	Africa	6569
Peru	155	-12.05	-77.05	Western Africa	Africa	7396
Philippines	156	14.6	120.98	South-Eastern Asia	Asia	13184
Pitcairn	247	-25.07	-130.1	Eastern Europe	Europe	12784
Poland	157	52.25	21	Southern Europe	Europe	4476
Portugal	158	38.72	-9.13	Melanesia	Oceania	1812
Puerto Rico	159	18.47	-66.11	Eastern Africa	Africa	5544
Qatar	160	25.29	51.53	Southern Africa	Africa	6242
Reunion	161	-20.87	55.47	Eastern Asia	Asia	7814
Romania	162	44.43	26.1	Southern	Europe	4382

				Europe		
Russia	163	55.75	37.62	Southern Asia	Asia	5973
Rwanda	164	-1.95	30.06	Northern Africa	Africa	4663
Saint Barthélemy	248	17.9	-62.85	South America	Americas	5221
Saint Helena	182	-15.93	-5.72	Southern Africa	Africa	3694
Saint Kitts and Nevis	183	17.3	-62.72	Northern Europe	Europe	5211
Saint Lucia	184	14	-61	Western Europe	Europe	5072
Saint Martin	249	18.08	63.08	Western Asia	Asia	7384
Saint Pierre and Miquelon	250	46.77	-56.18	Eastern Asia	Asia	5242
Saint Vincent and the Grenadines	185	13.13	-61.22	Central Asia	Asia	5106
Samoa	165	-13.83	-171.73	Eastern Africa	Africa	16467
San Marino	251	43.93	12.45	South-Eastern Asia	Asia	3283
Sao Tome and Principe	166	0.33	6.73	Western Africa	Africa	2679
Saudi Arabia	167	24.64	46.77	Polynesia	Oceania	5762
Senegal	168	14.7	-17.44	Polynesia	Oceania	899
Serbia	169	44.82	20.47	Caribbean	Americas	3945
Seychelles	171	-4.62	55.45	Northern Africa	Africa	7083
Sierra Leone	172	8.49	-13.23	Western Asia	Asia	1243
Singapore	173	1.29	103.86	Central Asia	Asia	11620
Slovakia	174	48.15	17.12	Caribbean	Americas	3912
Slovenia	175	46.06	14.51	Polynesia	Oceania	3579
Solomon Islands	176	-9.43	159.95	Caribbean	Americas	17330
Somalia	177	2.04	45.34	Eastern Africa	Africa	5907
South Africa	178	-25.71	28.23	Eastern	Europe	6056

				Europe		
South Georgia and the South Sandwich Islands	252	-54.28	-36.51	Eastern Europe	Europe	7926
South Korea	103	37.57	127	Northern Europe	Europe	13875
Spain	180	40.42	-3.7	Southern Europe	Europe	2096
Sri Lanka	181	6.93	79.85	South America	Americas	9160
Sudan	186	15.59	32.53	Central Asia	Asia	4354
Suriname	187	5.83	-55.17	Melanesia	Oceania	4686
Svalbard and Jan Mayen	253	78.22	15.63	South America	Americas	6330
Swaziland	188	-26.32	31.13	South-Eastern Asia	Asia	6292
Sweden	189	59.33	18.06	Polynesia	Oceania	4820
Switzerland	190	46.95	7.45	Western Asia	Asia	3195
Syria	191	33.5	36.3	Eastern Africa	Africa	4874
Taiwan	192	25.04	121.53	Eastern Africa	Africa	13232
Tajikistan	193	38.56	68.77	Southwestern Europe	Europe	8148
Tanzania	194	-6.18	35.75	Northern America	Americas	5366
Thailand	195	13.75	100.52	Asia	Asia	11145
Togo	197	6.13	1.22	Caribbean	Americas	1881
Tokelau	198	-9.2	-171.85	Asia	Asia	16388
Tonga	199	-21.13	-175.2	Asia	Asia	16971
Trinidad and Tobago	200	10.65	-61.52	Southeast Asia.	Oceania	5178
Tunisia	201	36.8	10.18	South America	South America	2640
Turkey	202	39.93	32.86	Northern Europe	Europe	4764
Turkmenistan	203	37.95	58.38	Antarctica	Antarctica	7123

Turks and Caicos Islands	204	21.47	-71.13	Southwestern Europe	Europe	6042
Tuvalu	205	-8.52	179.22	Northern North America	Americas	19217
U.S. Virgin Islands	217	18.36	-64.93	Western Europe	Europe	5426
Uganda	206	0.32	32.57	Western Europe	Europe	4783
Ukraine	207	50.43	30.52	Western Europe	Europe	5086
United Arab Emirates	208	24.47	54.37	Southeast Europe	Europe	6520
United Kingdom	209	51.51	-0.13	Central Europe	Europe	3261
United States	210	38.9	-77.04	Western Europe	Europe	6878
Uruguay	211	-34.86	-56.17	South Pacific Ocean	Oceania	7176
Uzbekistan	212	41.32	69.25	Oceania	Oceania	8259
Vanuatu	213	-17.73	168.32	Oceania	Oceania	18311
Vatican	254	41.9	12.45	Caribbean	Americas	3143
Venezuela	214	10.5	-66.92	Caribbean	Americas	5712
Vietnam	215	21.03	105.85	Northern North America	Americas	11657
Wallis and Futuna	219	-13.27	-176.17	Southern Europe	Europe	16890
Western Sahara	255	27.18	-13.06	Antarctica	Antarctica	692
Yemen	220	15.35	44.21	Europe	Europe	5518
Zambia	225	-15.42	28.28	Europe	Europe	5313
Zimbabwe	226	-17.82	31.04	Northern Africa	Africa	5679

APPENDIX E

ESS Models

- **All**

```
The regression equation is
N = 18.6 + 0.711 M
M= Ln(Product code*Country code*P(Disaster)* #of Dis*Exports market shear for the
country%)


Predictor      Coef   SE Coef       T      P    VIF
Constant    18.5863    0.0760  244.72  0.000
M          0.711276  0.009396   75.70  0.000  1.000


S = 1.67842   R-Sq = 79.0%   R-Sq(adj) = 79.0%


Analysis of Variance

Source            DF     SS     MS        F      P
Regression         1  16142  16142  5729.94  0.000
Residual Error  1524   4293      3
Total           1525  20435
```

- **Agricultural products**

```
The regression equation is
N = 19.3 + 0.528 M
M= Ln(Country code*P(Disaster)* #of Dis*Exports market shear for the country%)


Predictor     Coef  SE Coef       T      P    VIF
Constant   19.3312   0.1746  110.71  0.000
M          0.52781  0.02281   23.14  0.000  1.000


S = 0.776359   R-Sq = 84.9%   R-Sq(adj) = 84.8%


Analysis of Variance

Source          DF      SS      MS       F      P
Regression       1  322.61  322.61  535.25  0.000
Residual Error  95   57.26    0.60
Total           96  379.87
```

- **Automotive products**

```
The regression equation is
n = 19.6 + 0.712 m
M= Ln(Country code*P(Disaster)* #of Dis*Exports market shear for the country%)

Predictor     Coef  SE Coef      T      P    VIF
Constant   19.5617   0.2596  75.36  0.000
m          0.71224  0.02405  29.61  0.000  1.000


S = 1.19895   R-Sq = 90.1%   R-Sq(adj) = 90.0%
```

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	1260.7	1260.7	876.99	0.000
Residual Error	96	138.0	1.4		
Total	97	1398.7			

- **Chemicals**

The regression equation is
N = 17.4 + 1.00 M
M= Ln(Country code*P(Disaster)* #of Dis*Exports market shear for the country%)

Predictor	Coef	SE Coef	T	P	VIF
Constant	17.4416	0.0660	264.27	0.000	
M	1.00210	0.00783	128.01	0.000	1.000

S = 0.260159   R-Sq = 99.6%   R-Sq(adj) = 99.6%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	1109.1	1109.1	16386.92	0.000
Residual Error	64	4.3	0.1		
Total	65	1113.4			

- **Clothing**

The regression equation is
N = 18.8 + 0.705 M
M= Ln(Country code*P(Disaster)* #of Dis*Exports market shear for the country%)

Predictor	Coef	SE Coef	T	P	VIF
Constant	18.7943	0.2416	77.78	0.000	
M	0.70512	0.02606	27.05	0.000	1.000

S = 1.13141   R-Sq = 89.2%   R-Sq(adj) = 89.0%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	936.87	936.87	731.88	0.000
Residual Error	89	113.93	1.28		
Total	90	1050.80			

- **Electronic data processing and office equipment**

The regression equation is
N = 18.8 + 0.747 M
M= Ln(Country code*P(Disaster)* #of Dis*Exports market shear for the country%)

Predictor	Coef	SE Coef	T	P	VIF
Constant	18.7964	0.2936	64.02	0.000	
M	0.74659	0.02434	30.68	0.000	1.000

S = 1.29656   R-Sq = 90.7%   R-Sq(adj) = 90.6%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	1582.0	1582.0	941.10	0.000
Residual Error	96	161.4	1.7		
Total	97	1743.4			

- **Food**

The regression equation is
N = 19.2 + 0.527 M
M= Ln(Country code*P(Disaster)* #of Dis*Exports market shear for the country%)

Predictor	Coef	SE Coef	T	P	VIF
Constant	19.1526	0.1766	108.44	0.000	
M	0.52673	0.02313	22.77	0.000	1.000

S = 0.770594   R-Sq = 84.8%   R-Sq(adj) = 84.6%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	307.99	307.99	518.66	0.000
Residual Error	93	55.22	0.59		
Total	94	363.22			

- **Fuels**

The regression equation is
N = 20.7 + 0.662 M
M= Ln(Country code*P(Disaster)* #of Dis*Exports market shear for the country%)

Predictor	Coef	SE Coef	T	P	VIF
Constant	20.6723	0.2989	69.16	0.000	
M	0.66188	0.03542	18.69	0.000	1.000

S = 1.34516   R-Sq = 78.8%   R-Sq(adj) = 78.6%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	631.81	631.81	349.17	0.000
Residual Error	94	170.09	1.81		
Total	95	801.90			

- **Fuels and mining products**

The regression equation is
N = 20.4 + 0.595 M
M= Ln(Country code*P(Disaster)* #of Dis*Exports market shear for the country%)

Predictor	Coef	SE Coef	T	P	VIF
Constant	20.4017	0.2217	92.04	0.000	
M	0.59487	0.02739	21.72	0.000	1.000

S = 0.974192   R-Sq = 84.6%   R-Sq(adj) = 84.4%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	447.73	447.73	471.76	0.000
Residual Error	86	81.62	0.95		

Total	87	529.34

- **Integrated circuits and electronic components**

The regression equation is
N = 19.0 + 0.797 M
M= Ln(Country code*P(Disaster)* #of Dis*Exports market shear for the country%)

Predictor	Coef	SE Coef	T	P	VIF
Constant	18.9507	0.2940	64.46	0.000	
M	0.79679	0.02206	36.12	0.000	1.000

S = 1.37215   R-Sq = 93.5%   R-Sq(adj) = 93.5%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	2456.2	2456.2	1304.57	0.000
Residual Error	90	169.5	1.9		
Total	91	2625.7			

- **Iron and steel**

The regression equation is
N = 24.8 + 0.693 M
M= Ln(Country code*P(Disaster)* #of Dis*Exports market shear for the country%)

Predictor	Coef	SE Coef	T	P	VIF
Constant	24.7585	0.2539	97.50	0.000	
M	0.69320	0.02705	25.63	0.000	1.000

S = 1.26231   R-Sq = 87.4%   R-Sq(adj) = 87.2%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	1046.3	1046.3	656.65	0.000
Residual Error	95	151.4	1.6		
Total	96	1197.7			

- **Machinery and transport equipment**

The regression equation is
N = 21.0 + 0.678 M
M= Ln(Country code*P(Disaster)* #of Dis*Exports market shear for the country%)

Predictor	Coef	SE Coef	T	P	VIF
Constant	20.9748	0.2589	81.02	0.000	
M	0.67758	0.02577	26.29	0.000	1.000

S = 1.18648   R-Sq = 87.5%   R-Sq(adj) = 87.3%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	973.34	973.34	691.42	0.000
Residual Error	99	139.37	1.41		
Total	100	1112.70			

- **Manufactures**

The regression equation is
N = 21.7 + 0.654 M
M= Ln(Country code*P(Disaster)* #of Dis*Exports market shear for the country%)

Predictor	Coef	SE Coef	T	P	VIF
Constant	21.6616	0.2382	90.92	0.000	
M	0.65405	0.02516	25.99	0.000	1.000

S = 1.13739   R-Sq = 86.7%   R-Sq(adj) = 86.5%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	873.91	873.91	675.53	0.000
Residual Error	104	134.54	1.29		
Total	105	1008.45			

- **Office and telecom equipment**

The regression equation is
N = 20.1 + 0.745 M
M= Ln(Country code*P(Disaster)* #of Dis*Exports market shear for the country%)

Predictor	Coef	SE Coef	T	P	VIF
Constant	20.0522	0.2809	71.38	0.000	
M	0.74513	0.02475	30.11	0.000	1.000

S = 1.24881   R-Sq = 90.5%   R-Sq(adj) = 90.4%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	1413.9	1413.9	906.63	0.000
Residual Error	95	148.2	1.6		
Total	96	1562.1			

- **Pharmaceuticals**

The regression equation is
n = 18.9 + 0.745 m
M= Ln(Country code*P(Disaster)* #of Dis*Exports market shear for the country%)

Predictor	Coef	SE Coef	T	P	VIF
Constant	18.9279	0.2910	65.05	0.000	
m	0.74492	0.02800	26.61	0.000	1.000

S = 1.32358   R-Sq = 88.3%   R-Sq(adj) = 88.2%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	1240.2	1240.2	707.94	0.000
Residual Error	94	164.7	1.8		
Total	95	1404.9			

- **Telecommunications equipment**

```
The regression equation is
n = 19.2 + 0.743 m
M= Ln(Country code*P(Disaster)* #of Dis*Exports market shear for the country%)

Predictor     Coef  SE Coef      T      P    VIF
Constant   19.1587   0.2733  70.11  0.000
m          0.74330  0.02471  30.08  0.000  1.000


S = 1.19922   R-Sq = 90.7%   R-Sq(adj) = 90.6%


Analysis of Variance

Source          DF      SS      MS       F      P
Regression       1  1301.3  1301.3  904.83  0.000
Residual Error  93   133.7     1.4
Total           94  1435.0
```

- **Textiles**

```
The regression equation is
n = 18.0 + 0.654 m
M= Ln(Country code*P(Disaster)* #of Dis*Exports market shear for the country%)

Predictor     Coef  SE Coef      T      P    VIF
Constant   18.0128   0.2400  75.05  0.000
m          0.65390  0.02590  25.25  0.000  1.000


S = 1.11373   R-Sq = 86.9%   R-Sq(adj) = 86.8%


Analysis of Variance

Source          DF      SS      MS       F      P
Regression       1  790.70  790.70  637.45  0.000
Residual Error  96  119.08    1.24
Total           97  909.78
```